DEQ Water Quality Division

Analysis of Groundwater Nitrate Concentrations in the Lower Umatilla Basin Groundwater Management Area

February 23, 2012

State of Oregon
Department of Environmental Quality

Last updated: 02/23/12
By: Phil Richerson
12-WQ-019

This report prepared by:

Oregon Department of Environmental Quality
700 SE Emigrant, Suite 330
Pendleton, OR 97801
1-800-452-4011

Contact:
Phil Richerson
(541) 278-4604

This, as well as other LUB GWMA documents, can be found on the Department's web site at:

http://www.deq.state.or.us/wq/groundwater/lubgwma.htm

For printed copies, please contact the DEQ Eastern Region Office in Pendleton at (541) 276-4063.

Table of Contents

Figures

Tables

Appendices

Executive Summary

Introduction

This report summarizes groundwater nitrate concentrations and trends from wells within the Lower Umatilla Basin Groundwater Management Area (LUB GWMA). The data in this report came from a variety of well types and was generated by both private labs and governmental labs. The purpose of this document is to summarize the various groundwater nitrate data from within the GWMA into a single document, and to evaluate the LUB GWMA Action Plan measure of success that calls for decreasing nitrate concentrations throughout the GWMA by the end of 2009. Relevant points of reference for nitrate concentrations include the 10 milligram per liter (mg/l)[1] drinking water standard and the 7 mg/l GWMA trigger level[2] .

DEQ's LUB GWMA Well Network

DEQ began sampling a network of 38 wells in October 1991 for the purpose of tracking nitrate concentrations in the LUB GWMA. For a variety of reasons, the well network currently consists of 31 wells. Nitrate concentrations range from non-detectable (i.e., less than 0.005 mg/l) to 64 mg/l. Average nitrate concentrations at these wells range from 0.01 mg/l to 45.1 mg/l.

Approximately half of the wells exhibit increasing trends, one-quarter exhibit decreasing trends, and one-quarter exhibit statistically insignificant trends. Recent changes in nitrate trends (i.e., changes between trends through 2005 and trends through 2009) are approximately equally split between those that showed an improving trend (i.e., increasing less steeply or decreasing steeper), those that showed a worsening trend (increasing steeper or decreasing less steeply), and those that showed no change in trend.

The area-wide trend is increasing at 0.018 parts per million per year at a 99% confidence level. The area-wide trend has consistently been increasing over the past 12 years but at a progressively slower and slower rate. The nitrate trends in the LUB GWMA well network indicate the goal of a downward trend throughout most of the GWMA was not met.

Food Processor Land Application Sites

DEQ requires the installation and quarterly sampling of groundwater monitoring wells around twelve sites operated by six facilities in the LUB GWMA where food processing wastewater is treated through land application. Nitrate concentrations range from less than 0.02 mg/l to 129 mg/l. Average nitrate concentrations at these wells range from 0.2 mg/l to 63.3 mg/l.

Nitrate trends were calculated at 141 of these wells during at least one of three trend analyses conducted since 2001. In summary, nitrate trends are increasing at most wells and at most sites. Furthermore, the average nitrate concentration at most food processor sites exceeds the 7 mg/l GWMA trigger level.

The percentage of wells exhibiting increasing trends has decreased from 66% in the first analysis to 58% in the second analysis to 52% in the third analysis. During the same timeframe, the percentage of wells exhibiting decreasing trends increased from 5% in the first analysis to 18% in the second analysis to 22% in the third analysis. The percentage of flat and statistically insignificant trends has not changed much over time.

The reduction in the percentage of increasing trends coupled with the rise in the percentage of decreasing trends illustrates that improvements in groundwater quality are occurring in some areas. The fact that over twice as many wells still show increasing trends than show decreasing trends illustrates that more time and perhaps more

---

[1] Nitrate concentrations are typically reported in milligrams per liter (mg/l), which is essentially equal to parts per million (ppm). Both units of measure are used in this document.

[2] Oregon law requires establishment of a GWMA if groundwater nitrate concentrations exceed 7 mg/l.

changes in land application practices will be required to achieve the goal of an area-wide decreasing nitrate trend.

Three Mile Canyon Farms Wells

The Oregon Department of Agriculture requires the installation and sampling of monitoring wells in certain areas where water use practices and/or farm operations could impact groundwater quality. As of the end of 2009, 15 wells and 2 surface water bodies had been sampled enough to conduct a trend analysis.

Nitrate concentrations at the TMCF wells range from 2.82 ppm to 100.5 ppm, with average nitrate concentrations ranging from 4.0 ppm to 78.3 ppm. Thirteen of 15 wells exhibit nitrate concentrations greater than the 10 mg/l drinking water standard.

Nitrate trends are increasing at 33% of the wells, decreasing at 27% of the wells, and statistically insignificant at the remaining 40% of wells. Recent changes in nitrate trends (i.e., the difference between trends through 2005 and 2009) are approximately equally split between those that showed an improving trend and those that showed a worsening trend. The site-wide trend was calculated to be a statistically insignificant trend, but with a slightly decreasing slope. The analysis suggests a downward trend in nitrate levels may be occurring at the site.

Public Supply Wells

There are 59 public water supply systems in the LUB GWMA serving 39,554 people. Five of these systems (serving 437 people) require treatment for nitrate. In addition to the five systems with treatment, two systems (serving 1,800 people) drilled new wells because of groundwater nitrate contamination. Three public water supply wells were identified that had enough nitrate data from untreated water samples to perform a trend analysis.

Nitrate concentrations at these wells range from 0.17 mg/l to 12.9 mg/l while average nitrate concentrations range from 5.1 mg/l to 10.6 mg/l.

Two of the three wells exhibited increasing trends while the third well exhibited a statistically insignificant trend. Both public supply wells with data after 2005 show a slight improvement in nitrate trend in recent years.

Synoptic Sampling Events

As a supplement to the regularly sampled LUB GWMA well network, DEQ has conducted three synoptic sampling events since the GWMA was established. The intent of these sampling events is to provide a "snapshot" of groundwater nitrate concentrations throughout the GWMA. The first synoptic sampling event was conducted in 1992 and included 207 wells. The third synoptic sampling event was conducted from September 2009 through January 2010 and included 107 wells.

Nitrate concentrations from the third synoptic sampling event ranged from not detected (i.e., less than 0.005 mg/l) to 103.4 mg/l and averaged 14.7 mg/l. More than half of the wells (58%) exhibited nitrate concentrations greater than the 7 mg/l GWMA trigger level.

A comparison of nitrate concentrations at 98 wells sampled during the first and third synoptic sampling events indicate the mean, median, and maximum nitrate concentrations observed were higher in the third event than in the first event. In addition, 54% of wells showed a significant increase in nitrate concentration while 24% showed a significant decrease in nitrate concentrations, and 22% showed no significant change in nitrate concentration. A comparison of nitrate concentrations from the first and third synoptic sampling event suggests an upward trend in nitrate levels is occurring throughout most of the GWMA.

Depot Landfill Wells

The 20-acre landfill located in the northeast portion of the Umatilla Chemical Depot is surrounded by 14 monitoring wells. Five of these wells have been tested for nitrate frequently enough since June 1988 to allow calculation of a trend. The landfill was closed and capped by November 1997.

Nitrate concentrations at these five wells range from 1.8 ppm to 17 ppm and average more than 10 ppm. Four of these five wells (80%) exhibit decreasing trends. One well exhibited a statistically insignificant trend. No well showed an increasing trend. Recent changes in nitrate trends at the Depot landfill wells generally show improving trends (i.e., increasing less steeply).

The site-wide trend calculated using data from all five wells indicates that a decreasing nitrate trend is evident 14 years after the landfill was closed and capped.

Real Estate Transaction Database

Oregon's Revised Statute 448.271(1) requires property owners who are selling real estate that includes a domestic well to test the water for arsenic, nitrate, and total coliform bacteria. For a variety of reasons, the quality of the data from this source is the lowest of all sources of data evaluated. Nitrate concentrations ranged from not detected at 0.1 mg/l to 56 mg/l. Eighty three percent of the results from 372 wells were below the 7 mg/l GWMA trigger level. About 10% of results exceeded the 10 mg/l drinking water standard. Approximately 38% of results were less than 1 mg/l suggesting no influence from human activities.

Summary of Nitrate Concentrations and Trends

Nitrate Concentrations - Nitrate data from seven different sources and representing approximately 650 wells were evaluated in this study. Each group of data contained wells with nitrate concentrations so low that no contamination from human activities is evident. Each group also contains wells with nitrate concentrations that exceed the 7 mg/l GWMA trigger level and the 10 mg/l drinking water standard. At least three of these groups contain wells with maximum concentrations greater than 100 mg/l.

About 40% of the wells exhibited nitrate concentrations above the 7 mg/l GWMA trigger level. If the lower quality data from the Real Estate Transaction Database is not considered, 64% of the wells exceeded the 7 mg/l GWMA trigger level.

Nitrate Trends - Nitrate trends were calculated at 201 wells. The timeframe of each data set is different but 95% of the data sets end in late 2009. Half of the wells analyzed (51%) exhibit an increasing trend while 24% exhibit a decreasing trend, 1% exhibit a flat trend, and 24% exhibit statistically insignificant trends.

While not a calculated trend, a comparison of the nitrate concentrations at the 98 wells sampled during the first and third synoptic sampling events show 54% increased, 24% decreased, and 22% did not change.

The proportions of increasing, decreasing, and statistically insignificant trends within the regularly sampled LUB GWMA network of 31 wells are very similar to the proportions of all 201 wells tested, as well as the comparison of the 98 synoptic sampling event wells. This similarity suggests the network provides a reasonable representation of the GWMA as a whole.

Primary Conclusion

The LUB GWMA Action Plan measure of success that calls for decreasing nitrate concentrations throughout the GWMA by the end of 2009 was not met.

Recommendation

The LUB GWMA Committee and sub-committees should consider this report when drafting the next Four-Year Evaluation of Action Plan Success and the next LUB GWMA Action Plan.

REGISTERED PROFESSIONAL GEOLOGIST SEAL

In accordance with Oregon Revised Statutes Chapter 672.505 to 672.705, specifically ORS 672.605 that states:

"All drawings, reports, or other geologic papers or documents, involving geologic work as defined in ORS 672.505 to 672.705 which shall have been prepared or approved by a registered geologist or a subordinate employee under the direction of a registered geologist for the use of or for delivery to any person or for public record within this state shall be signed by the registered geologist and impressed with the seal or the seal of a nonresident practicing under the provisions of ORS 672.505 to 672.705, either of which shall indicate responsibility for them.",

I hereby acknowledge that the document cited below was prepared by me.

Document Title: Analysis of Groundwater Nitrate Concentrations in the Lower Umatilla Basin Groundwater Management Area

Document Author(s): Phil M. Richerson

Document Date: Date: February 23, 2012

Name of Oregon RPG: Phil M. Richerson (G1906)

Signature of Oregon RPG: Phil Richerson

Date of Seal: 2/23/12

1.0 Introduction

This report summarizes groundwater nitrate concentrations and trends from wells within the Lower Umatilla Basin Groundwater Management Area (LUB GWMA). The data in this report came from a variety of well types (i.e., monitoring wells, irrigation wells, industrial wells, private drinking water wells, and public drinking water wells), and was generated by both private labs and governmental labs. The purpose of this document is to summarize the various groundwater nitrate data from within the GWMA into a single document, and to evaluate the LUB GWMA Action Plan measure of success that calls for decreasing nitrate concentrations throughout the GWMA by the end of 2009. This document will also provide a context for preparation of the next LUB GWMA Action Plan.

1.1 Establishment of the Lower Umatilla Basin Groundwater Management Area

Oregon's Groundwater Protection Act of 1989 requires the Oregon Department of Environmental Quality (DEQ) to declare a Groundwater Management Area (GWMA) if area-wide groundwater contamination, caused primarily by nonpoint source pollution, exceeds certain trigger levels. In the case of nitrate, the trigger level is 7 mg/l. Nonpoint source pollution of groundwater results from contaminants coming from diffuse land use practices, rather than from discrete sources such as a pipe or ditch. The contaminants of nonpoint source pollution can be the same as from point source pollution, and can include sediment, nutrients, pesticides, metals, and petroleum products. The sources of nonpoint source pollution can include construction sites, agricultural areas, forests, stream banks, roads, and residential areas.

The Groundwater Protection Act also requires the establishment of a local Groundwater Management Area Committee composed of affected and interested parties. The Committee works with and advises the state agencies that are required to develop an action plan that will reduce groundwater contamination in the area.

The DEQ declared the LUB GWMA in 1990 after nitrate contamination was identified in a 352,000-acre area in the northern portions of Umatilla and Morrow counties (Figure 1-1). Groundwater samples from private wells had nitrate contamination above the federal safe drinking water standard in many samples collected from the area. DEQ, the Oregon Water Resources Department, and the Oregon Health Division conducted a four-year comprehensive study of the area in the early 1990s. This study resulted in a 1995 report titled "Hydrogeology, Groundwater Chemistry, & Land Use in the Lower Umatilla Basin Groundwater Management Area". The study identified five potential sources of nitrate loading to groundwater:

1. Confined Animal Feeding Operations (i.e., dairies and feed lots),
2. Irrigated Agriculture,
3. Land Application of Food Processing Wastewater,
4. Septic Systems (rural residential areas), and
5. The Umatilla Chemical Depot Washout Lagoons

DEQ and the Committee finalized the LUB GWMA Action Plan in December 1997. The Action Plan details the activities to be conducted by the various agencies and organizations involved. The Umatilla and Morrow County Soil and Water Conservation Districts are the local agencies leading implementation of the Action Plan. DEQ and the Oregon Department of Agriculture (ODA) have oversight responsibility. Local governments, private industry, and the US Army are also involved in implementation of the Action Plan.

DEQ and the Committee decided to implement the Action Plan on a voluntary basis recognizing that individuals, businesses, organizations, and governments will, if given adequate information and encouragement, take positive actions to adopt or modify practices and activities to reduce contaminant loading to groundwater.

The Action Plan recommends general activities and specific tasks to be conducted by involved agencies and groups representing the five sources of nitrate loading. The Action Plan also identifies methods and a schedule for evaluating progress in implementing the Action Plan.

The Action Plan requires an evaluation of Action Plan Success every four years. The continued voluntary nature of the Action Plan is assessed as part of each four-year evaluation.

1.2 Purpose of this Report

The purpose of this document is to summarize the various groundwater nitrate data from within the GWMA into a single document, and to evaluate the LUB GWMA Action Plan measure of success that calls for decreasing nitrate concentrations throughout the GWMA by the end of 2009. This measure of progress is identified in the Action Plan in the following places:

- Section VII, Items C.3 and C.4 call for both a qualitative and quantitative evaluation of the action plan's progress and success be conducted 12 years after action plan adoption (i.e., after 2009).
- Section VII, Item E describes the quantitative evaluation to be conducted, including Section VIII, Item E.3.b, which states the evaluation of success will depend (in part) on the "evaluation of nitrate changes along several groundwater flow paths from upgradient to downgradient sites".
- Section VII, Item G.1.e identifies a downward nitrate trend as a goal for the irrigated agriculture sector,
- Section VII, Item G.2.d.3 identifies a downward nitrate trend as a goal for the rural residential sector,
- Section VII, Item G.3.d.1 identifies a downward nitrate trend as a goal for the food processor sector,
- Section VII, Item G.4.d.1 identifies a downward nitrate trend as a goal for the CAFO sector, and
- Section VII, Item G.5.d.1 identifies a downward nitrate trend as a goal for the Army Depot washout lagoons.

1.3 Scope of this Report

Section VII, Item E of the Action Plan describes the quantitative evaluation to be conducted. It identifies the DEQ bi-monthly well network as the source of data to be used in the trend analysis. It also calls for an evaluation of nitrate changes along several groundwater flow paths from upgradient to downgradient sites. Finally, it calls for an evaluation of "other factors" associated with a reduction in the loading of nitrate to the groundwater such as long-term trends in nitrate levels of shallow and deep soil samples.

This document describes nitrate concentrations and trends from the following sources:

- *DEQ's LUB GWMA Well Network -* consisting of approximately 32 private drinking water and irrigation wells sampled every other month for 19 years,
- *Food Processor Site Well Network* - consisting of approximately 113 private monitoring wells and irrigation wells sampled quarterly for 2 to 23 years,
- *Three Mile Canyon Farms Well Network* – consisting of 15 private monitoring wells sampled quarterly for 4 to 9 years,
- *Public Supply Wells* – consisting of 3 public water supply wells sampled approximately quarterly for approximately 3 to 26 years,
- *Synoptic Sampling Events* – consisting of 3 large sampling events (~100 wells per sampling event) conducted between 1992 and 2009,
- *Depot Landfill Wells* – consisting of 5 wells installed around the Umatilla Chemical Depot landfill, and
- *Real Estate Transaction Database* – consisting of 413 samples collected from 372 wells sampled up to three times between 1989 and 2009.

2.0 Methods

The methods selected for evaluation of nitrate data were based on the Action Plan, recommendations from previous studies, and literature research. The methods used to evaluate nitrate trends are discussed below.

2.1 Analysis of Data Where Nitrate Was Not Detected

Results from some wells were sometimes reported as below the nitrate detection limit[3] (e.g., <0.005 mg/l). For those wells with some non-detected values, two values were entered into the electronic files for each result. The first value was the measured concentration for detected concentrations or the detection limit for non-detected values. The second value was a code indicating if the first value represents a detected concentration or the detection limit for a non-detected observation.

The data where nitrate was not detected were recorded in this manner to allow more statistically robust evaluations of data set characteristics and trends. The procedures recommended in Helsel (2005) for computing summary statistics and calculating trends were followed using macros written by Dr. Helsel for use within Minitab. These include the following:

- For wells with a small amount of non-detected values, the mean and median were calculated by the Kaplan-Meier method using the KMStats macro.
- For wells with a significant amount of non-detected values, the mean and median were calculated by the Maximum Likelihood Estimation method using the MLEBoot macro.
- Trends at wells with non-detected values were calculated by the Akritas-Theil-Sen version of Kendall's robust line fit. The Turnbull estimate of median residual is used as the intercept. This is a nonparametric regression line based on Kendall's tau correlation coefficient. The ATS macro was used for these calculations.
- Seasonality at wells with non-detected values was evaluated using the nonparametric Kruskal-Wallis test for comparing medians. The CensKW macro was used for these calculations.

2.2 Trend Analyses at Individual Wells

Nitrate results from wells with no non-detected values were analyzed for a monotonic trend using the Seasonal Kendall test. The Seasonal Kendall test was developed by the USGS in the 1980s and has become the most frequently used test for trends in the environmental sciences (Helsel, et.al. 2006). The Seasonal Kendall test performs separate tests for trends in each season, and then combines the results into one overall linear trend result.

The Seasonal Kendall test accounts for seasonality by computing the Mann-Kendall test on each season separately, and then combining the results. For example, February data are compared only to February data. No comparisons are made across seasonal boundaries. The overall Seasonal Kendall trend slope is computed as the median of all slopes between data points within the same season. No cross-season slopes contribute to the overall estimate of the Seasonal Kendall trend slope. This slope is the median rate of change over time. This overall result reflects whether there is a trend with time for that location, blocking out all seasonal differences in the pattern of change (Helsel and Frans, 2006). The Seaken macro written by Dr. Helsel for use within Minitab was used to calculate trends at individual wells. Results of the individual well trend analyses are discussed in subsequent sections of this report.

In addition to calculating the monotonic trends at each well, LOWESS lines through the data were also calculated for each well. LOWESS stands for LOcally WEighted Scatterplot Smoothing (Cleveland et al., 1979). It is not a monotonic trend analysis technique. It is a data smoothing algorithm that uses a moving window superimposed over a graph of the data, with analyses being performed with each move, to produce a smoothed relationship between the two variables. Data near the center of the moving window influences the

[3] In the statistical literature, data reported as below or above a detection limit are called "censored" data.

smoothed value more than those farther away. The smoothed relationship is then plotted as the LOWESS line. It provides a graphical depiction of the underlying structure of the data.

An advantage of LOWESS is that no model, such as a linear or quadratic function, is assumed prior to computing a smoothed line. As such, LOWESS is an exploratory tool for discerning the form of relationship between y and x. Because no model form is assumed, the data describe the pattern of dependence of y on x. LOWESS is particularly useful to emphasize the shape of the relationship between two variables on a scatterplot of moderate to large sample size.

Because a LOWESS line reflects the underlying pattern of the data and is not fitting a straight line through the data as all monotonic trend techniques do, it allows an evaluation of changes over time. For example, a monotonic trend analysis result may indicate a statistically significant downward trend in a water quality variable over a 10-year period. However, the LOWESS line may suggest that the water quality variable decreased for 8 years and increased during the last 2 years. As another example, a monotonic trend analysis result may not identify a statistically significant trend in a water quality variable over a 10-year period. However, the LOWESS line may suggest that the water quality variable increased for 5 years then decreased for 5 years. These observations might be valuable and would not be apparent from a monotonic trend analyses.

2.3 Evaluation of Area-Wide Trend

The measures of Action Plan success regarding nitrate trends relate to changes "throughout most of the GWMA." A variation of the Seasonal Kendall test called the Regional Kendall test was used to evaluate the area-wide trend as well as site-wide trends at the food processor land application sites, the Three Mile Canyon Farms site, and the Umatilla Depot landfill.

Helsel and Frans (2006) describe the test as follows. The Regional Kendall test is a test to determine whether a consistent pattern of trend occurs across an entire area, at multiple locations. The Regional Kendall test substitutes location for season and computes the equivalent of the Seasonal Kendall test. The Regional Kendall test looks for consistency in the direction of trend at each location, and tests whether there is evidence for a general trend in a consistent direction throughout the region. Patterns at an individual location occurring in the same direction as the regional trend provide some evidence toward a significant regional trend, even if there is insufficient evidence of trend for that one location.

The Seaken macro written by Dr. Helsel for use within Minitab was used to calculate the linear area-wide trend. Results of the area-wide nitrate trend analysis are discussed in subsequent sections of this report.

3.0 Results From DEQ's LUB GWMA Well Network

This section describes the LUB GWMA well network data set as well as the nitrate concentrations and trends exhibited at the wells.

3.1 Description of Data Set

DEQ began sampling a network of 38 wells in October 1991. Since that time, some well owners have decided to end their participation, while other wells are no longer in use. Therefore, the well network currently consists of 31 wells. This well network was sampled every other month from October 1991 through November 2009. Starting in 2010, this well network was sampled four times per year. Most of the wells in the DEQ well network are private drinking water wells. The network also contains a wastewater lagoon monitoring well, an industrial water supply well, and an irrigation well (also used as a monitoring well). The results of the monitoring are discussed below.

3.2 Nitrate Concentrations and Trends at Individual Wells

A basic component of the evaluation of trends at individual wells is the time versus concentration graph. Time versus nitrate concentration graphs for each well are included as Appendix A. Also included on the graphs in Appendix A are the monotonic trends and a LOWESS line (which provides an indication of the general pattern of the data).

Trend analysis results include two basic pieces of information for each test performed: a slope value and a confidence level. The slope indicates the direction and magnitude of the trend while the confidence level indicates the statistical certainty of the result. Trends are either increasing (i.e., have a positive slope), decreasing (i.e., have a negative slope), or flat (i.e., have a slope of zero). For Lower Umatilla Basin GWMA studies, test results with confidence levels less than 80% are considered "statistically insignificant". This does not mean that the concentrations observed at these wells are insignificant or unworthy of attention. Instead, this means that the statistical test could not identify a linear trend with a high degree of assurance. All statistically insignificant trends are grouped together in this report. Statistically significant trends are divided into increasing, decreasing, or flat trends. Results of nitrate trend analyses at individual wells are summarized in Table 3-1.

Table 3-1 includes summary statistics and the nitrate trends at all 38 wells for the entire history of the well network (i.e., since October 1991). Nitrate concentrations range from non-detectable (i.e., less than 0.005 mg/l) to 64 mg/l. Average nitrate concentrations at these wells range from 0.01 mg/l to 45.1 mg/l.

The summary at the bottom of Table 3-1 indicates the types of trends from all 38 wells and just the 31 currently sampled wells. An examination of Table 3-1 reveals the 31 currently sampled wells exhibit 15 increasing trends (48%), 7 decreasing trends (23%), 1 flat trend (3%), and 8 statistically insignificant trends (26%). If all 38 wells are considered, the percentage of increasing trends is higher (55%) while the percentage of decreasing trends is slightly lower (21%).

Figure 3-1 illustrates the LOWESS lines and trend lines through the nitrate data at all network well locations. Each graph on Figure 3-1 is at the same scale to allow a direct comparison of trends between locations. Because a few wells are so much higher than most wells, many LOWESS lines appear nearly flat in Figure 3-1. The graphs in Appendix A provide a more useful tool for looking at changes at an individual well. Useful information can be gained by comparing trend lines with LOWESS lines. For example, the monotonic trend at well UMA084 indicates an overall decreasing trend, but the LOWESS line indicates concentrations are increasing in the latter portion of the data set. Similarly, the monotonic trend at well UMA028 indicates an increasing trend, but the LOWESS line indicates concentrations are decreasing in the latter portion of the data set.

It is noteworthy that four of the eight wells exhibiting statistically insignificant trends have average nitrate concentrations above the target concentration of 7 ppm, including the well with the highest average nitrate concentration (45.1 ppm at well UMA029). The fact that statistically significant trends cannot be drawn through the data at some wells indicates that the data are not "well behaved" (i.e., the data exhibit significant variability) and may suggest a shift in trend direction within the data set. For example, nitrate concentrations at well UMA034 (page A-2 in Appendix A) not only exhibit seasonality (e.g., concentrations are generally highest in May and lowest in November), but generally increased in the 1990s, decreased through about 2005, then increased through 2009. The monotonic trend calculated with these data is not statistically significant.

It is also noteworthy that the 10 ppm drinking water standard was exceeded at least once in 21 of the 38 wells (55%); and that the average nitrate concentration exceeded the drinking water standard in 14 of the 38 wells (37%).

The steepest increasing trends are at two wells that are no longer being sampled: 1.46 ppm/yr at UMA085 and 1.56 ppm/yr at well UMA122. The property ownership for the land with well UMA085 changed, and the new owner did not want to participate in the sampling program. The owner of well UMA122 drilled a new well and decommissioned well UMA122. The steepest increasing trend at a currently sampled well is 0.94 ppm/yr at well UMA201.

The steepest decreasing trend is at a well that is no longer being sampled: -0.61 ppm/yr at well UMA058. This well is a production well located at the Simplot facility that was decommissioned about a year after the facility closed. The steepest decreasing trend at a currently sampled well is -0.36 ppm/yr at well UMA133.

In conclusion, approximately half of the wells exhibit increasing trends, one quarter exhibit decreasing trends, and one quarter exhibit statistically insignificant trends, and the average slope of all trends is increasing. Examination of the LOWESS line through the nitrate data illustrates more subtle changes in concentration over time. Trends are often more complicated than a straight line. Water quality changes seen in the data are smoothed by the LOWESS line and distilled into a straight line by the trend analysis. The smoothing often highlights changes over time while a straight line over-simplifies changes.

Determining why specific wells exhibit high concentrations and/or steeply increasing trends could provide useful information in identifying best management practices that could reduce nonpoint source pollution and/or identifying point source contamination sources that should be addressed.

3.3 Recent Changes in Individual Nitrate Trends

Recent changes in nitrate trends at individual LUB GWMA network wells are summarized in Table 3-2. Table 3-2 includes the trends at each well through 2009 (as indicated in Table 3-1) as well as the trend at each well through 2005. The numerical difference between the two trend slopes is presented as well as a description of whether the change in slope represents an improvement or worsening of the nitrate trend, regardless of the statistical significance of the trends[4]. As indicated in Table 3-2, the trends worsened at 10 wells, improved at 10 wells, and showed no change at 11 wells. The average and median changes were larger in worsening trends, but the largest single change was evident in an improving trend (UMA029 improved by 0.54 ppm/yr). The confidence level changed enough to change the statistical significance of the trend at seven wells. The trend changed direction at one well: UMA029 switched from a statistically significant increasing trend to a statistically insignificant trend with a decreasing slope.

[4] Improvements include when an increasing trend becomes less increasing or when a decreasing trend becomes more decreasing. Worsening trends include increasing trends that became more increasing or when a decreasing trend becomes less decreasing.

In summary, recent changes in nitrate trends at individual LUB GWMA network wells are approximately equally split between those that showed an improving trend, those that showed a worsening trend, and those that showed no change in trend.

3.4 Nitrate Trends versus Geographic Location

Figure 3-2 illustrates the locations of all 38 network wells and the type of trend at each well. Figure 3-2 illustrates that the increasing trends and statistically insignificant trends occur throughout the network. In contrast, the decreasing trends typically occur in the southern and eastern portion of the network. The exception is well UMA038 located in the city of Umatilla. The one flat trend is well UMA187 located near the southern boundary of the GWMA in the Butter Creek valley that is screened beneath a caliche layer and almost always has non-detectable levels of nitrate.

3.5 Area-Wide Trend

3.5.1 Area-Wide Trend Through 2009

Figure 3-3 illustrates the data used to evaluate the area-wide trend from 1991 through 2009, as well as the results of the evaluation. Figure 3-3 consists of many stacks of data points at two-month intervals. Each of these stacks of data points represents one sampling event and contains one data point for each well sampled during that event. The data set used to calculate the area-wide trend included 3,719 data points collected from up to 38 wells from 110 different sampling events.

The Regional Kendall test estimated the area-wide trend to be increasing at 0.018 ppm/year at a 99% confidence level. This result is illustrated in Figure 3-2 with the dashed line. The LOWESS line through all the data is also illustrated in Figure 3-2. The LOWESS line starts at about 6.7 ppm then increases to about 7.7 ppm by mid-1999, then decreases to about 6.7 by the end of 2009.

Figure 3-3 shows there are fewer data points between about 20 and 40 mg/l in the early portion of the data set than in the later portion of the data set. This data distribution is consistent with an overall increasing trend.

Figure 3-3 shows that many of the high nitrate values are from two wells: UMA029 and UMA085. As indicated in Section 3.2, well UMA085 is no longer being sampled because property ownership changed, and the new owner did not want to participate in the sampling program. Well UMA029 continues to be sampled. Nitrate concentrations at UMA029 appear to be decreasing in recent years but still remain well above the drinking water standard.

As indicated in Section 2.3, the area-wide trend was calculated using the Regional Kendall test for trend. The Regional Kendall test was set up such that each "well/month sampled" combination was defined as a "season". For example, each sample from well UMA033 sampled in March of any year was designated as belonging to season "UMA033March". There are 18 data points in the UMA033March "season". Each "season" contained between 9 and 20 data points, with most having 15 to 18 data points.

There were 228 such "seasons" using the 3,719 data points in the area-wide trend calculation. Of those 228 "seasons", 142 (62%) were increasing, 79 (35%) were decreasing, and seven (3%) were flat. Increasing seasons ranged in slope from 0.001 to 1.72 ppm/yr. Decreasing seasons ranged in slope from -0.0003 to -1.11 ppm/yr.

In other words, there are more increasing "seasons" than decreasing "seasons", and the increasing trends are steeper than the decreasing trends. This is consistent with the increasing area-wide trend.

3.5.2 Area-Wide Trend Over Time

In order to evaluate the change in area-wide trend over time, the full data set described above (i.e., October 1991 through November 2009) was trimmed of all data collected in 2009. This trimmed data set (i.e., October 1991 through November 2008) was then tested with the Regional Kendall test. This procedure was repeated ten more times, producing the following estimates of the area-wide trend over time.

Timeframe	Years of data	Area-Wide Trend	
		Slope (ppm/yr)	Confidence Level
Oct 1991 thru Nov 1998	7	0.098	99%
Oct 1991 thru Nov 1999	8	0.080	99%
Oct 1991 thru Nov 2000	9	0.075	99%
Oct 1991 thru Nov 2001	10	0.066	99%
Oct 1991 thru Nov 2002	11	0.062	99%
Oct 1991 thru Nov 2003	12	0.050	99%
Oct 1991 thru Nov 2004	13	0.040	99%
Oct 1991 thru Nov 2005	14	0.037	99%
Oct 1991 thru Nov 2006	15	0.032	99%
Oct 1991 thru Nov 2007	16	0.025	99%
Oct 1991 thru Nov 2008	17	0.023	99%
Oct 1991 thru Nov 2009	18	0.018	99%

These results indicate the area-wide trend has consistently been increasing, but at progressively slower and slower rates.

In conclusion, the nitrate trends in the LUB GWMA well network indicate the goal of a downward trend throughout most of the GWMA was not met. This measure of progress relates to the entire GWMA as a December 2009 goal for all five sources of nitrate. This goal, as well as the other December 2009 goals, will be evaluated in a separate document titled "Third Four-Year Evaluation of Action Plan Success".

4.0 Results From Food Processor Land Application Sites

This section summarizes results from the recent document titled "Third Trend Analysis of Food Processor Land Application Sites in the Lower Umatilla Basin Groundwater Management Area" hereafter referenced as DEQ (2011). All three trend analyses are available at http://www.deq.state.or.us/wq/groundwater/lubgwma.htm.

4.1 Description of Data Set

DEQ requires the installation and quarterly sampling of groundwater monitoring wells around twelve sites operated by six facilities in the LUB GWMA where food processing wastewater is treated through land application. Some of these wells have been sampled since 1987. Most wells analyzed have been installed and sampled since the mid-1990s. Other wells were installed much more recently and do not yet have enough data to perform a trend analysis. Nitrate trends were calculated at 141 of these wells during at least one of the three trend analyses. There are currently 113 wells at these sites with enough data to analyze. The results of the analyses are presented in detail in DEQ (2011) and summarized below.

4.2 Nitrate Concentrations and Trends at Individual Wells

Section 3.2 of this document discusses the importance of a time versus concentration graph in performing a trend analysis as well as how to interpret the results of a trend analysis. Time versus concentration graphs for the food processor wells are provided in Appendix 1 through six of DEQ (2011). Nitrate concentrations at these wells range from less than 0.02 mg/l to 129 mg/l while average nitrate concentrations range from 0.2 mg/l to 63.3 mg/l (DEQ, 2011).

Figure 4-1 illustrates the location and type of trend at the 141 wells that were analyzed at least once. As of the end of 2009, 113 of these wells were still being sampled. Table 4-1 summarizes the nitrate trends at these 113 wells as well as the site-wide trend, and the site-wide average nitrate concentrations from the time of well installation through 2009 (which covers variable lengths of time). This type of summary gives the best overview of all available data at each site. Also indicated in Table 4-1 for each site is the site-wide trend and site-wide average nitrate concentration from 2005 through 2009. This type of summary allows a direct comparison of nitrate trends and concentrations between sites over a specific timeframe.

The table indicates that most wells (54%; 61 of 113) exhibited increasing trends while 20% of wells (23 of 113) exhibited decreasing trends, 1% (1 of 113) exhibited a flat trend, and 25% (28 of 113) exhibited statistically insignificant trends.

In addition to the 113 wells in Table 4-1, two wells downgradient of the ConAgra Madison Ranch site were also evaluated. Results from those wells indicated two decreasing trends.

Additional observations made from Table 4-1 that highlights the overall picture of elevated and increasing nitrate concentrations include:

- The site-wide trend is increasing at eight sites,, decreasing at two sites, statistically insignificant at one site, and flat at one site.
- The site-wide average nitrate concentration is above the 7 mg/l GWMA trigger level at 10 of 12 sites.

Observations made from Table 4-1 that highlight improvements in nitrate concentrations trends during the 2005 through 2009 timeframe include:

- There are fewer sites with an increasing trend and more sites with decreasing trends. The site-wide trend is increasing at five sites, decreasing at four sites, and statistically insignificant at three sites.
- Eight of 12 sites show improving site-wide nitrate trends (i.e., increasing less steeply)
- Four of 12 sites show lower site-wide average nitrate concentrations.

Figure 4-2 provides a different way to compare all 113 trends. All 113 trends are illustrated both as a bar graph and as box plots. Figure 4-2(a) is a bar graph in which the length of the bar indicates the timeframe of the data evaluated, and the vertical position of the bar on the graph indicates the nitrate trend. Figure 4-2(b) is a box plot of the 87 statistically significant trends, the 26 statistically insignificant trends, and all 113 trends. As noted in Figure 4-2, 50% of the trends are between -0.03 and 0.6 ppm/yr, while 88% of the trends are between 2.0 and -0.50 ppm/yr.

The timeframe of the data used to calculate the 113 trends ranged from 2.2 to 22.5 years. The average timeframe was 14.3 years. Half of the wells had between 12.5 and 18.1 years of data. An examination of Figure 4-2(a) does not suggest a relationship between the length of the data set and the trend slope (i.e., the shorter time frames are not grouped together). In order to statistically evaluate the potential correlation between data set length and trend slope, the nonparametric Kendall's Tau correlation coefficient was calculated. The correlation coefficient indicates a very low coefficient (0.0003; with a p-value of 0) indicating there is no correlation between data set length and trend slope.

In summary, the trend analysis of food processor wells indicates that nitrate concentrations are increasing at most wells, and at most sites. Furthermore, the average nitrate concentration at most food processor sites exceeds the GWMA trigger level. However, the trend analysis does not by itself provide an indication of whether or not the nitrate contamination is the result of current facility operations. Other factors that can affect nitrate concentrations include historical facility activities, offsite activities (both current and historical), and the site's hydrogeology. Factors affecting the timing of groundwater quality improvement, as well as potential methods to assess current facility operations are discussed in DEQ (2007).

4.3 Comparison of Trends at Wells Analyzed Multiple Times

Nitrate trends at wells analyzed during multiple trend analyses are compared in Table 4-2. 103 wells were analyzed in both the second and third trend analyses. Because well networks at the Port of Morrow Farm 3 and the Simplot Levy Site were not yet in place in 2001, and some wells at other sites were added or dropped, only 88 of these wells were analyzed in the first trend analysis. Because the number of wells analyzed varied, the percentage of wells exhibiting each type of trend is also indicated in Table 4-2.

Table 4-2 compares the numbers of various types of trends (e.g., increasing or decreasing), the average trend slope, and the average of the average nitrate concentration between the first, second, and third trend analyses at each site[5]. Because the well networks changed over time at some sites, the number of wells used in Table 4-2 is less than the total number of wells analyzed.

The summary at the bottom of Table 4-2 includes a comparison of the following aspects of the two analyses as well as the change between the two analyses:

- number of various types of trends (e.g., increasing or decreasing) at each site,
- average trend slope at each site, and
- the average of average nitrate concentrations at each well.

The Table 4-2 summary highlights the following indications of improving water quality between the two analyses:

- there were 6% fewer increasing trends and 4% more decreasing trends, and
- the average trend slope improved at 75% of the sites.

[5] While the average of the average nitrate concentrations may or may not closely approximate the true population average, the change in the average of the average nitrate concentrations does reflect a change in nitrate concentrations because the same wells were used each time averages were calculated.

The Table 4-2 summary also highlights the following indication of worsening water quality between the two analyses.

- the site-wide average (i.e., the average of the average concentrations at each well) worsened at 67% of the sites.

In other words, while nitrate concentrations are increasing at most wells and at most sites, and average nitrate concentration at most sites exceeds the GWMA trigger level, the rate of increase is slower than it was during the previous analysis.

Figure 4-3 illustrates the changes in trends at wells analyzed in each of the three analyses. Figure 4-3 shows that the percentage of wells exhibiting increasing trends has decreased from 66% in the first analysis to 58% in the second analysis to 52% in the third analysis. During the same timeframe, the percentage of wells exhibiting decreasing trends has increased from 5% in the first analysis, to 18% in the second analysis, to 22% in the third analysis. The percentage of flat trends and statistically insignificant trends has not changed much over time.

In summary, the reduction in the percentage of increasing trends coupled with the rise in the percentage of decreasing trends illustrates that improvements in groundwater quality are occurring. The fact that over twice as many wells still show increasing trends than show decreasing trends illustrates that more time and perhaps more changes in land application practices will be required to achieve the goal of an area-wide decreasing nitrate trend.

Information gathered from the analysis of 113 wells at 12 food processor land application sites do not suggest that a downward trend in nitrate levels is occurring throughout most of the GWMA. This measure of progress relates to the entire GWMA as a December 2009 goal for all five sources of nitrate. This goal, as well as the other December 2009 goals, will be evaluated in a separate document titled "Third Four-Year Evaluation of Action Plan Success".

5.0 Results From Three Mile Canyon Farms

This section describes the Three Mile Canyon Farms (TMCF) well network data set as well as the nitrate concentrations and trends exhibited at the wells.

5.1 Description of Data Set

The Oregon Department of Agriculture (ODA) requires Three Mile Canyon Farms to conduct groundwater quality sampling in certain areas where water use practices and/or farm operations could impact groundwater quality. As of the end of 2009, 15 wells and 2 surface water locations have been sampled enough to conduct a trend analysis. The results of the analysis are discussed below.

5.2 Nitrate Concentrations and Trends at Individual Locations

Section 3.2 of this document discusses the importance of a time versus concentration graph in performing a trend analysis as well as how to interpret the results of a trend analysis. Time versus concentration graphs for the TMCF wells are provided in Appendix B.

Figure 5-1 illustrates the location and type of trend at the 15 TMCF wells and the two surface water locations analyzed. Table 5-1 summarizes the nitrate concentrations and trends at these locations. The starting date and ending dates for these data sets are not all the same.

Groundwater Nitrate Concentrations and Trends

Table 5-1 indicates that nitrate concentrations at the TMCF wells range from 2.82 ppm at well SU-1 to 100.5 ppm at Simplot well MW-7. Average nitrate concentrations at these 15 wells range from 4.0 ppm at well SU-1 to 78.3 ppm at Simplot well MW-7. Thirteen of 15 wells exhibit nitrate concentrations greater than the 10 ppm drinking water standard.

Table 5-1 also indicates that 33% of the wells (5 of 15) exhibited increasing trends, 27% of wells (4 of 15) exhibited decreasing trends, and 40% (6 of 15) exhibited statistically insignificant trends. The average slope of all 15 trends is decreasing at 0.13 ppm/yr. The average slope of the nine statistically significant trends is decreasing at 0.70 ppm/yr.

Surface water Nitrate Concentrations and Trends

Sixmile Canyon Pump 2 is located along the northeast boundary of the farm at a point of diversion in Sixmile Canyon. Surface water is pumped from this location for irrigation on both sides of Sixmile Creek (Figure 5-1).

The Office Pond is located in the north central portion of farm (Figure 5-1). Because the Office Pond receives water from the extensive subsurface drain system on the farm, it is somewhat of a composite groundwater sample representing a significant portion of the farm. Water is pumped from the Office Pond into the farms irrigation system.

Table 5-1 indicates that nitrate concentrations at the two surface water locations (i.e., Sixmile Canyon Pump 2 and the Office Pond) range from 2.1 ppm at Sixmile Canyon Pump 2 to 42.2 ppm at the Office Pond. The average nitrate concentration at Sixmile Canyon Pump 2 is 14.4 ppm while the average nitrate concentration at the Office Pond is 27.7 ppm.

Table 5-1 also indicates the nitrate trends at the two surface water locations are statistically insignificant. The time series plot in Appendix B illustrates the seasonality of nitrate concentrations at Sixmile Canyon Pump 2 (i.e., nitrate concentrations are typically highest in the winter and spring, and lowest in the summer and fall). The LOWESS line through the Sixmile Canyon Pump 2 data decreases from 2000 into 2002, then increases through 2004.

Nitrate data in the Office Pond do not exhibit statistically significant seasonality (perhaps due in part to the non-regular sampling frequency). The data do, however, tend to be higher in spring and lower in summer and fall.

5.3 Recent Changes in Individual Nitrate Trends

Recent changes in nitrate trends at the Three Mile Canyon Farms wells are summarized in Table 5-2. Table 5-2 includes the trends at each well through 2009 (as indicated in Table 5-1) as well as the trend at each well through 2005. The numerical difference between the two trend slopes is presented as well as a description of whether the change in slope represents an improvement or worsening of the nitrate trend, regardless of the statistical significance of the trends[6]. As indicated in Table 5-2, the trends worsened at six wells and improved at five wells. The average, median, and maximum changes were larger in improving trends. A lack of data during specific time periods prohibited the calculation of a trend at four wells. The confidence level changed enough to change the statistical significance of the trend at four wells. The trend changed direction at one well: Simplot well MW-7 switched from increasing at 8.9 ppm/yr to decreasing at 2.83 ppm/yr.

In summary, recent changes in nitrate trends at Three Mile Canyon Farm wells are approximately equally split between those that showed an improving trend and those that showed a worsening trend.

5.4 Nitrate Trends versus Geographic Location

Figure 5-1 shows the locations of the 15 wells and the type of trend at each well. Increasing and decreasing trends occur throughout the well network. There is no discernible pattern of increasing or decreasing trends at these 15 locations.

5.5 Site-Wide Trend

Figure 5-2 illustrates the data used to evaluate the site-wide trend from 2000 through 2009, as well as the results of the evaluation. Figure 5-2 consists of many stacks of data points at three month intervals. Each of these stacks of data points represents one sampling event and contains one data point for each well sampled during that event. The data used to calculate the site-wide trend included 342 data points collected from the wells.

The Regional Kendall test estimated the site-wide trend from 2000 through 2009 to be statistically insignificant, but with a slightly decreasing slope. Similarly, the site-wide trend from 2005 through 2009 was also statistically insignificant with a decreasing slope. The LOWESS line through all the data decreases from 2000 into 2003, then slightly increases through 2009. The analysis of the 15 TMCF wells suggests a downward trend in nitrate levels may be occurring at the site.

Figure 5-2 illustrates that most of the nitrate concentrations above 50 ppm occur at two wells: Simplot MW-7 and CWU-2. Nitrate concentrations at well Simplot MW-7 increased from about 60 ppm in early 2003 to about 100 ppm in 2005 then decreased to about 60 ppm by 2008. Nitrate concentrations at well CWU-2 ranged from approximately 45 to 90 ppm in 2000 into 2003, then decreased rapidly to less than 10 by early 2005 where they stayed through 2009.

---

[6] Improvements include when an increasing trend becomes less increasing or when a decreasing trend becomes more decreasing. Worsening trends include increasing trends that became more increasing or when a decreasing trend becomes less decreasing.

6.0 Results From Public Supply Wells

This section summarizes trend analysis results from three public supply wells within the LUB GWMA that had enough untreated nitrate data to perform a trend analysis.

6.1 Description of Data Set

As summarized in Table 6-1, there are 59 public water supply systems within the LUB GWMA serving 39,554 people. Five of these systems (serving 437 people) require treatment for nitrate. In addition to the five systems with treatment, two systems (serving 1,800 people) drilled new wells because of nitrate contamination.

DEQ staff consulted with Oregon Department of Health Services (now known as the Oregon Health Authority) Drinking Water Program staff to identify public water supply systems within the LUB GWMA that had enough nitrate data from untreated water samples to perform a trend analysis. Three such systems were identified. Time series plots showing nitrate concentrations and trends from the three systems analyzed are presented in Appendix C. Results of the trend analysis at these three wells are presented in Table 6-2 and discussed below.

6.2 Results of Analysis

Country Garden Estates Mobile Home Park – Country Garden Estates is located in Irrigon and serves 110 people. The water supply is from an 84.5' deep well open to one foot of gravelly sand and one-half foot of hard basalt. Nitrate data in the Drinking Water Program's database for this well include 22 results from June 1984 through June 2010. As illustrated in Figure C-1 in Appendix C, these 22 results are not equally spaced over time, so seven data points were trimmed from the data set to space the data as equally as possible. This trimmed data set ranges from 0.17 mg/l to 9.8 mg/l, exhibits an average of 5.12 mg/l, and a statistically insignificant trend. The trend exhibits an increasing slope (0.15 mg/l per year) but is deemed statistically insignificant due to its low confidence level (64%). The LOWESS line increases from the first sample in 1984 until about 2001 when it begins to decrease.

City of Hermiston Well #5 – The city of Hermiston's water supply comes from five wells and a Columbia River diversion. The City delivers water to 15,410 residents. One of their wells (well #5) has elevated nitrate levels. Well #5 is 103 feet deep and open to sand, gravel, conglomerate, and sandstone between the approximate depths of 26 and 90 feet below land surface. Nitrate data from the Drinking Water Program's database for this well include 28 results from November 1987 through August 2010. As illustrated in Figure C-2 of Appendix C, these 28 results are not equally spaced in time, so nine data points were trimmed from the data set to space the data as equally as possible. This trimmed data set ranges from 0.51 mg/l to 7 mg/l, exhibits an average of 5.1 mg/l, and an increasing trend of 0.1 mg/l per year with a 90% confidence level. The LOWESS line increases from 1987 through about 1997, then levels off through about 2004, then increases again into 2010.

Upper Columbia Mill – Upper Columbia Mill is located near Boardman and serves 50 people. The water supply is from a 324' deep well. The well is cased to 138' (through sand, gravel, and claystone) into basalt and is open to 186' of claystone and basalt. The well was installed in 1978 for DBS Farms. The property changed ownership several times, most recently being purchased by Greenwood Resources in 2007.

Water was initially observed at 120' but dropped to 148' when the well was finished. Nitrate data in the Drinking Water Program's database for this well include 13 results from March 2008 through January 2011. A nitrate treatment system was installed in January 2011 so additional untreated samples will not be collected. As illustrated in Figure C-3, this data set ranges from 5.59 mg/l to 12.9 mg/l, exhibits an average of 10.6 mg/l, and an increasing trend of 0.66 mg/l per year with an 82% confidence level. The LOWESS line increases in 2008, decreases in 2009, and increases in 2010.

This well is an example of the importance of proper well construction. The Drinking Water Program staff evaluated the well construction details and concluded the well construction was not adequate. The amount of cement used to create a seal was less than required. It is unusual to find nitrate contamination in a well completed several hundred feet into the basalt. It is likely that shallow water contaminated with nitrate is migrating down the borehole to the deeper basalt aquifer.

6.3 Recent Changes in Individual Nitrate Trends

Recent changes in nitrate trends at the Public Water Supply wells are summarized in Table 6-3. Table 6-3 includes the trends at each well through 2010 (as indicated in Table 6-2) as well as the trend at each well through 2005. The numerical difference between the two trend slopes is presented as well as a description of whether the change in slope represents an improvement or worsening of the nitrate trend, regardless of the statistical significance of the trends[7]. As indicated in Table 6-3, the trends improved slightly at two wells. The average, median, and maximum changes were about 0.03 ppm/yr. A lack of data prior to 2005 prohibited the calculation of a trend at one well. The confidence level changed enough to change the statistical significance of the trend at both wells.

In summary, both public supply wells with data after 2005 show a slight improvement in nitrate trend in recent years (i.e., it is increasing slightly less steeply than before).

6.4 Conclusions

Based on the information discussed above, the following conclusions regarding nitrate concentrations and trends in public supply wells are made:

- There are 59 public water supply systems within the LUB GWMA serving 39, 554 people.
- Five of these systems (serving 437 people) require treatment for nitrate.
- In addition to the five systems with treatment, two systems (serving 1,800 people) drilled new wells because of nitrate contamination.
- Proper well construction (e.g., an adequate seal above the well screen) is important to minimize the potential for contaminated water to move from one aquifer to another.
- Nitrate concentrations range from 0.17 mg/l to 12.9 mg/l while average nitrate concentrations at these wells range from 5.1 mg/l to 10.6 mg/l.
- Three of 59 public water supply systems had enough untreated nitrate data to perform a trend analysis.
    - Two of three wells analyzed exhibited statistically significant increasing trends. The third well showed a statistically insignificant trend.
    - Nitrate concentrations at these wells range from 0.17 ppm to 12.9 ppm.
    - One of these wells exhibited concentrations above the 10 ppm drinking water standard until treatment was installed.
    - Both public supply wells with data after 2005 show a slight improvement in nitrate trend in recent years.
- The analysis of groundwater nitrate trends at three public supply wells do not suggest a downward trend in nitrate levels is occurring throughout most of the GWMA.

[7] Improvements include when an increasing trend becomes less increasing or when a decreasing trend becomes more decreasing. Worsening trends include increasing trends that became more increasing or when a decreasing trend becomes less decreasing.

7.0 Results From Synoptic Sampling Events

This section describes the results from the third synoptic sampling event in the LUB GWMA. In addition, the results are compared to the first synoptic sampling event. Results of previous synoptic sampling events are described in the "2003 Lower Umatilla Basin Groundwater Management Area Synoptic Sampling Event Report" available at http://www.deq.state.or.us/wq/groundwater/lubgwma.htm.

7.1 Description of Data Set

From September 2009 through January 2010, 107 wells were sampled as part of the third LUB GWMA synoptic sampling event. The intent of the sampling event was to provide a third "snapshot" of groundwater nitrate concentrations throughout the GWMA.

7.2 Results of Analysis

Nitrate concentrations from the third synoptic sampling event are presented in Table 7-1. Nitrate concentrations from the 107 wells sampled ranged from not detected (i.e., < 0.005 mg/l) to 103.4 mg/l. The data are not normally distributed, but rather are skewed towards smaller concentrations. This skewness causes the median nitrate concentration to be 8.7 mg/l while the average is 14.7 mg/l. The interquartile range (i.e., the middle half of the data) ranges from 3.0 to 18.3 mg/l.

Nitrate Concentrations By Location

Figure 7-1 presents the results of the third synoptic sampling event in the form of colored dots on a map. The dots indicate the locations of wells tested. The dots are coded using cool colors (i.e., blue, cyan, and green) to represent wells with nitrate concentrations below the 7 mg/l GWMA trigger level and warm colors (i.e., yellow, orange, and red) to represent wells with nitrate concentrations above the 7 mg/l GWMA trigger level.

As indicated in Figure 7-1, 42% of the wells exhibited nitrate concentrations less than the 7 mg/l GWMA trigger level while 58% of the wells exhibited nitrate concentrations greater than the 7 mg/l GWMA trigger level.

Changes in Nitrate Concentration

The first synoptic sampling event was conducted in June and July 1992 and included 207 wells. The third synoptic sampling event was conducted between September 2009 and January 2010 and included 107 wells. Ninety-eight of the 107 wells sampled in the third event were also sampled in the first event. Ninety-five of the 98 wells sampled in both events exhibited different concentrations during the two events. Differences ranged from less than 1 mg/l to approximately 50 mg/l. Statistical measures of nitrate concentrations at wells sampled in both events were higher in the third event than in the first event. For example, the 1992 median nitrate concentration was 6.2 mg/l while the 2009 median concentration was 8.05 mg/l. Similarly, the 1992 average concentration was 10.47 while the 2009 average concentration was 14.32 mg/l. Finally, the 1992 maximum concentration was 67 mg/l while the 2009 maximum concentration was 103.4 mg/l.

In order to evaluate the potential for analytical variability to account for the observed differences between the first and third Synoptic Sampling Events, the relative percent difference (RPD) between the two nitrate concentrations was calculated. The DEQ lab that generated these data require replicate samples (i.e., two samples of the same water collected at the same time but put into two different containers) be within a RPD of 10%.

The RPD between the two nitrate concentrations is as follows:

- 11 wells had a RPD <10% (actual difference ranged from 0.02 to 1.0 mg/l)
- 82 wells had a RPD >10% (actual difference ranged from 0.026 to 52.9 mg/l)
- Five wells had at least one result below detectable levels so a RPD could not be calculated.

As indicated above, some wells with a RPD >10% exhibited a small actual difference in concentration. In order to identify wells with a "significant change in concentration" (defined here as having a RPD >10% and an actual difference of more than 0.5 mg/l, wells exhibiting actual differences of less than 0.5 mg/l were removed from consideration. Removing these 22 wells from consideration leaves 76 wells exhibiting a "significant difference in concentration".

Of the 98 wells sampled twice, 53 wells (54%) showed a significant increase in nitrate concentration while 23 wells (24%) showed a significant decrease in nitrate concentration. Twenty-two wells (22%) showed no significant change in nitrate concentration. Significant increases in nitrate concentration ranged from 0.51 mg/l to at least 36.4 mg/l. Significant decreases in nitrate concentration ranged from 0.73 mg/l to 49 mg/l.

Figure 7-2 is a map depicting significant changes in nitrate concentrations between these two sampling events. A color-coded symbol is located at each well location indicating the change in nitrate concentration at that well. As indicated in Figure 7-2 and discussed above, more wells showed a significant increase in nitrate concentration than a significant decrease in nitrate concentration. However, there does not seem to be a systematic geographic correlation with changes in nitrate concentration.

Largest Increase in Nitrate Concentration

When the 1992 and 2009 synoptic sampling event results are compared, the largest increase in nitrate concentration (59.2 mg/l) appears to have occurred at well UMA273. The reported value from the 1992 event is 0.10 mg/l. The reported value from the 2009 synoptic sampling event is 53 mg/l. However, as explained in DEQ (2006), the 1992 reported value of 0.10 mg/l is suspected to be an error.

If well UMA273 is not considered, the next largest increase in nitrate concentration occurred at well UMA161. The reported value from the 1992 event is 67 mg/l (which was the highest nitrate value reported during that sampling event). The reported value from the 2009 synoptic sampling event is 103.4 mg/l (which was the highest nitrate value reported during that sampling event). The nitrate concentration increased 36.4 mg/l between these two sampling events.

Nitrate Concentrations by Well Type

The 107 wells tested during the third synoptic sampling event fall into four categories based on intended use: 42 domestic wells, 2 industrial wells, 9 irrigation wells, and 54 monitoring wells. The industrial wells include the deep basalt well at the PGE Boardman Plant and a shallow well next to the City of Echo wastewater lagoon. The monitoring wells were installed near potential contaminant sources and are located in and around food processor land application sites, the City of Irrigon sewage lagoon, two agricultural areas, and the Depot landfill.

Figure 7-3 is a map depicting well types. A color-coded symbol is located at each well location indicating the type of well. As indicated in Figure 7-3, even though the sampled monitoring wells are clustered together at specific sites, and the sampled domestic wells are scattered around, there is substantial overlap in the geographic areas covered by these wells. The domestic wells extend further northeast than the monitoring wells while the monitoring wells extend further southwest than the domestic wells. Five of the nine irrigation wells are located between Boardman and Irrigon while the other irrigation wells are located south of the Depot, west of Hermiston, within Hermiston, and west of Echo.

Figure 7-4 presents the total depth of the wells sampled during the third synoptic sampling event in the form of box plots[8] by well type. Well depths ranged from 17.6' to 350' and averaged 89'. Half of the wells were between 46' and 113' deep.

---

[8] Box Plot Explanation – The lower limit of the box is the 25th percentile (i.e., 25% of the data is less than this value). The upper limit of the box is the 75th percentile. The height of the box is the interquartile range (IQR). The box contains the middle 50% of the data. A line drawn across the box indicates the median value. The symbol indicates the average value. Heights of the two box halves depict the skewness (e.g., if the top half is larger the data is positively skewed). Vertical lines are drawn from the top and bottom of the box to the farthest data points within 1.5 times the IQR. Any data point beyond this distance is plotted individually.

The deepest well sampled was a 350 foot deep industrial well at the PGE Boardman facility. This well is screened in basalt and had no detectable nitrate (less than 0.005 mg/l). The other industrial well sampled was a 22.5 foot deep well at the City of Echo wastewater lagoon that had 0.71 mg/l nitrate. The second deepest well sampled was a 330' deep domestic well west of the Butter Creek valley. This well produces water from a gravel layer and had 4.48 mg/l nitrate. All of the remaining wells are less than 190 feet deep.
Figure 7-4 shows the total depths of the domestic wells, irrigation wells, and monitoring wells appear similar. Having only two industrial wells severely limits what can be said about industrial wells as a group, and how industrial wells compare to other groups. Similarly, having only nine irrigation wells limits what can be said about irrigation wells as a group, and how irrigation wells compare to other groups. On the other hand, having 42 domestic wells and 54 monitoring wells allows a comparison of these two groups of wells.

The Kruskal-Wallis test of equal medians does not indicate a statistically significant difference between the depths of domestic wells, irrigation wells, and monitoring wells. In other words, the domestic wells, irrigation wells, and monitoring wells are approximately the same depth.

Figure 7-5 presents the nitrate results of the third synoptic sampling event in the form of box plots by well type. As indicated in Figure 7-5, the highest concentration (103.4 mg/l) and the highest median concentration (18 mg/l) were observed at irrigation wells. Monitoring wells exhibited a lower median concentration (12.3 mg/l) while the domestic wells exhibited an even lower median (4.8 mg/l). The two industrial wells exhibited the lowest median concentration (less than 1 mg/l).

The Kruskal-Wallis test of equal medians indicates there is a difference in nitrate concentrations between these two groups of wells. In other words, monitoring wells generally have higher nitrate concentrations than domestic wells.

There were 24 wells with nitrate concentrations greater than 20 mg/l: 17 monitoring wells, four domestic wells, and three irrigation wells. This represents about one-third of the monitoring wells and irrigation wells, but only 10% of the domestic wells.

In conclusion,

- monitoring wells generally exhibit higher nitrate concentrations than domestic wells of similar depths and
- the comparison of groundwater nitrate concentrations between the first and third synoptic sampling events suggest an upward trend in nitrate levels is occurring throughout most of the GWMA.

8.0 Results From Depot Landfill Wells

This section describes the evaluation of nitrate data from five monitoring wells around the landfill located at the Umatilla Chemical Depot.

8.1 Description of Data Set

The Depot landfill is located in the northeast portion of the Umatilla Chemical Depot. The 20-acre landfill is a former gravel pit that received garbage, demolition debris, asbestos from brake linings, and dried sludge (including domestic wastewater sludge) from 1950 through 1968. Ash from the Deactivation Furnace and explosive sludges may also have been placed in the landfill. During more recent years, the landfill was used for disposal of solidified/stabilized wastes from remedial activities occurring within the Depot boundaries. Final closure and landfill cap construction were completed in November 1997.

Five of the 14 monitoring wells located near the landfill have been tested for nitrate frequently enough since June 1988 to allow calculation of a trend. Because the sample frequency changed over time, the data sets were trimmed to semiannual results for this analysis. All Depot landfill wells are screened in sediments above the basalt and range in depth from 122' to 170' deep.

8.2 Nitrate Concentrations and Trends at Individual Wells

Section 3.2 of this document discusses the importance of a time versus concentration graph in performing a trend analysis as well as how to interpret the results of a trend analysis. Time versus concentration graphs for the Depot Landfill wells are provided in Appendix D.

Figure 8-1 illustrates the location and type of trend at the five Depot landfill wells tested. Table 8-1 summarizes the nitrate concentrations and trends at these locations.

Table 8-1 indicates that nitrate concentrations at the Depot landfill wells range from 1.8 ppm at well 11-5 to 17 ppm at MW-33 and MW-35. Average nitrate concentrations at these five wells range from 10.8 ppm at well 11-5 to 14.5 ppm at well MW-33.

Table 8-1 also indicates that 80% of the wells (4 of 5) exhibited decreasing trends, and 20% (one well) exhibited a statistically insignificant trend. No wells exhibited an increasing trend. The average slope of all five trends is decreasing at 0.11 ppm/yr. The average slope of the four statistically significant trends is decreasing at 0.13 ppm/yr.

8.3 Recent Changes in Individual Nitrate Trends

Recent changes in nitrate trends at the Depot landfill wells are summarized in Table 8-2. Table 8-2 includes the trends at each well through 2010 (as indicated in Table 8-1) as well as the trend at each well through 2005. The numerical difference between the two trend slopes is presented as well as a description of whether the change in slope represents an improvement or worsening of the nitrate trend, regardless of the statistical significance of the trends[9]. As indicated in Table 8-2, the trends worsened at one well and improved at four wells. The change was larger in the worsening trend than in the improving trends. The confidence level changed enough to change the statistical significance of the trend at three wells. The trend changed direction at one well: MW-36 switched from a statistically insignificant trend with a positive slope of 0.01 ppm/yr to a trend decreasing at 0.06 ppm/yr.

In summary, recent changes in nitrate trends at the Depot landfill wells generally show improving trends.

[9] Improvements include when an increasing trend becomes less increasing or when a decreasing trend becomes more decreasing. Worsening trends include increasing trends that became more increasing or when a decreasing trend becomes less decreasing.

8.4 Site-Wide Trend

Figure 8-2 illustrates the data used to evaluate the area-wide trend from 1988 through 2010, as well as the results of the evaluation. Figure 8-2 consists of many stacks of data points at six-month intervals. Each of these stacks of data points represents one sampling event and contains one data point for each well sampled during that event. The data used to calculate the site-wide trend included 164 data points collected from the wells.

The Regional Kendall test estimated the site-wide trend from 1988 through 2010 to be decreasing at 0.1 ppm/yr. The LOWESS line through all the data increases slightly in the early 1990s but then decreases through 2010.

The analysis of nitrate concentrations at the Depot landfill indicates a decreasing nitrate trend is evident 14 years after the landfill was closed and capped.

9.0 Results From Real Estate Transaction Database

9.1 Description of Data Set

Oregon Revised Statute (ORS) 448.271(1) requires property owners who are selling real estate that includes a domestic well to test the water for arsenic, nitrate, and total coliform bacteria. Test results must be reported within 90 days to the real estate buyer and the Drinking Water Program after the seller receives the test results. These data are entered into the Real Estate Transaction (RET) Database accessible through the Pacific Northwest Water Quality Data Exchange.

The quality of the data in the RET database is the lowest of all data sets analyzed. The low quality is due to the variability in the way samples are collected and analyzed as well as how the results are reported and transcribed into the database. Obvious errors have been identified in the database (e.g., Section Township Range designations that do not correspond to the identified County) so it is likely more subtle errors such as transcription errors or inaccurate location coordinates are also in the database. Furthermore, there are also reported instances of people sampling treated water (e.g., already passed through a reverse osmosis filter) rather than untreated water so that the reported results are below the drinking water standard.

9.2 Results of Analysis

In April 2011, Oregon Health Authority staff queried the Pacific Northwest Water Quality Data Exchange for all nitrate and bacteria records within the LUB GWMA, and then transmitted the data to DEQ. These records represent 413 results from 372 wells. Unfortunately, the information in the database does not include well depth or the OWRD Well ID so it is not possible to directly determine if these wells tap the alluvial aquifer or the basalt aquifer. This limits the usefulness of the data in this context.

Figure 9-1 presents the results of the RET database query in the form of colored dots on a map. The dots indicate the locations of wells tested. The dots are coded using cool colors (i.e., blue, cyan, and green) to represent wells with nitrate concentrations below the 7 mg/l GWMA trigger level and warm colors (i.e., yellow, orange, and red) to represent wells with nitrate concentrations above the 7 mg/l GWMA trigger level.

Figure 9-1 illustrates that the tested wells are clustered in specific areas with the majority of wells in a northeast/southwest trending zone north of Hermiston. Other clusters of wells occur east of Stanfield, near Irrigon, south of Boardman, and between Irrigon and Umatilla. Eighty three percent of wells tested have nitrate concentrations less than the 7 mg/l GWMA trigger level. About 10% of results exceeded the 10 mg/l drinking water standard. Approximately 38% of results were less than 1 mg/l suggesting no influence from human activities.

Most of the wells with the highest nitrate concentrations (six of eight wells with greater than 20 mg/l nitrate) are located near Boardman. However, there does not appear to be a distinctive geographic pattern of nitrate concentrations. In fact, large differences in short distances can be observed. For example, between Irrigon and Umatilla there is one "blue" well within 600 feet of a "red" well.

Thirty-seven wells had been sampled multiple times. Of these wells, nine wells increased between sampling events, 12 wells decreased between sampling events, and 16 wells showed no significant change. Potential seasonal changes in groundwater quality makes drawing conclusions about long-term trends at these wells difficult to determine.

Average nitrate concentration and median nitrate concentration were plotted to look for patterns. The number of samples per year ranged from zero to 57, so it is difficult to conclude much from this kind of evaluation.

Analysis of nitrate concentrations from the real estate transaction database confirmed the presence of elevated nitrate concentrations in the LUB GWMA but did not suggest anything about nitrate trends in the alluvial aquifer.

10.0 Summary of Nitrate Concentrations and Trends

This section compiles and summarizes the nitrate concentration and trend information from the seven different sources of data.

10.1 Nitrate Concentrations

Table 10-1 is a summary of the nitrate concentrations from the seven different sources of groundwater nitrate data within the LUB GWMA. Approximately 650 wells[10] are represented in Table 10-1. Approximately 480 wells are represented by a single nitrate concentration (i.e., those sampled during the third synoptic sampling event and most results from the real estate transaction database). Two hundred and three wells are represented by dozens of data points (i.e., those within existing monitoring well networks). Average nitrate values were used in Table 10-1 for regularly sampled wells. Otherwise, individual nitrate concentrations were used.

As indicated in Table 10-1, wells within each of group show a range of nitrate concentrations. Groups of wells with the smallest number of wells show the smallest range in concentrations. Each group contains wells with nitrate concentrations so low that no contamination from human activities is evident. Each group also contains wells with nitrate concentrations that exceed the 7 mg/l GWMA trigger level and the 10 mg/l drinking water standard. At least three of these groups contain wells with maximum concentrations greater than 100 mg/l.

The percentage of wells with average nitrate concentrations greater than the 7 mg/l GWMA trigger level ranged from 20% (for the Real Estate Transaction Database wells) to 100% (for the Depot landfill wells). Similarly, the percentage of wells with nitrate greater than the 10 mg/l drinking water standard ranged from 11% (for the Real Estate Transaction Database) to 100% (for the Depot landfill wells). The frequently sampled monitoring well networks exhibited higher percentages of high nitrate concentrations.

As indicated in Section 9, in addition to the quality of the data in the Real Estate Transaction database being the lowest of all data sets analyzed, it is also not possible to identify whether these wells tap the alluvial aquifer (the focus of the GWMA) or the basalt aquifer. Therefore, two summaries are presented at the bottom of Table 10-1: one that includes the RET database and one that excludes the RET database.

As indicated in Table 10-1, if the RET database is included, 40% of wells sampled within the LUB GWMA have average nitrate concentrations above the 7 mg/l GWMA trigger level. On the other hand, if the RET database is excluded, 64% of wells have average nitrate concentrations above the 7 mg/l GWMA trigger level.

10.2 Nitrate Trends

Table 10-2 is a summary of the nitrate trends calculated at 201 wells from five of the seven difference sources of groundwater nitrate data within the LUB GWMA.

The timeframe of each data set is different but 95% of the data sets end in late 2009. Table 10-2 indicates 51% of the wells analyzed exhibit an increasing trend, 24% exhibit a decreasing trend, 1% exhibited a flat trend, and 24% exhibit statistically insignificant trends.

The 38 wells of the LUB GWMA well network exhibited 55% increasing trends, 21% decreasing trends, 3% flat trends, and 21% statistically insignificant trends. The 140 food processing site monitoring wells showed similar percentages (i.e., 53% increasing, 24% decreasing, 1% flat and 23% statistically insignificant). Two of the three public supply wells were increasing (the other is statistically insignificant).

---

10 Due to the uncertainty of the identify of wells in the Real Estate Transaction database, it is possible some of the wells were also sampled as part of the synoptic sampling event. Furthermore, one well (UMA198) is known to be sampled as part of the LUB GWMA well network and the food processing site monitoring well network. Finally, the LUB GWMA well network was sampled as part of the Third Synoptic Sampling Event. Therefore, the actual number of wells represented in Table 10-1 is likely around 650.

The Three Mile Canyon Farms well network exhibited more increasing trends (5 wells) than decreasing trends (4 wells), but had even more statistically insignificant trends (6 wells).

The Depot landfill wells are the only data set with no increasing wells. Eighty percent of the five Depot landfill wells are decreasing in nitrate concentration. The other well showed a statistically insignificant trend.

While not a calculated trend, a comparison of the nitrate concentrations at the 98 wells sampled during the first and third synoptic sampling events show 54% increased, 24% decreased, and 22% did not change.

The proportions of increasing, decreasing, and statistically insignificant trends within the regularly sampled LUB GWMA network of 31 wells are very similar to the proportions of all 201 wells tested, as well as the comparison of the 98 synoptic sampling event wells. This similarity suggests the network provides a reasonable representation of the GWMA as a whole.

10.3 Summary

Figure 10-1 consists of three pie charts summarizing the percentage of wells exceeding the 7 mg/l GWMA trigger level nitrate concentration, and the types of trends at a subset of these wells. Figures 10-1(a) and 10-1(b) are pie charts showing the percentage of wells with an average nitrate concentration greater than 7 mg/l if the Real Estate Transaction Database is included or excluded, respectively. Average nitrate concentrations were used in Figure 10-1 for regularly sampled wells. Otherwise, individual nitrate concentrations were used.

Figure 10-1(a) indicates that if the RET database is included, 40% of wells tested have an average nitrate value greater than the 7 mg/l GWMA trigger level. Because some of the 372 wells included in the RET database are likely tapping the basalt aquifer (which is typically lower in nitrate concentration), the percentage of alluvial aquifer wells with an average nitrate concentration greater than 7 mg/l is likely higher than 40%.

Figure 10-1(b) indicates that if the RET database is excluded, 64% of wells tested have an average nitrate value greater than the 7 mg/l GWMA trigger level. The actual percentage of wells with an average nitrate value greater than 7 mg/l is unknown but if one-third of the wells were basalt wells with concentrations below 7 mg/l, the percentage of alluvial aquifer wells with concentrations above 7 mg/l would be about 50%.

Figure 10-1(c) shows the relative percentage of the types of trends evident at 201 wells tested. Figure 10-1(c) indicates 51% increasing trends, 24% decreasing trends, 24% statistically insignificant trends, and 1% flat trends.

Based on the nitrate trends discussed above, the LUB GWMA Action Plan measure of success that calls for decreasing nitrate concentrations throughout the GWMA by the end of 2009 was not met.

11.0 Conclusions and Recommendation

11.1 Conclusions

Based on the discussion above and the goals of the LUB GWMA Action Plan, the following conclusions are made:

LUB GWMA Well Network

- Approximately half of the wells exhibit increasing trends, one quarter exhibit decreasing trends, and one quarter exhibit statistically insignificant trends, with the average slope of all trends is increasing.
- Recent changes in nitrate trends at individual LUB GWMA network wells are approximately equally split between those that showed an improving trend (i.e., increasing less steeply or decreasing steeper), those that showed a worsening trend (i.e., increasing steeper or decreasing less steeply), and those that showed no change in trend.
- The area-wide trend has been consistently increasing over the past decade, but at a progressively slower and slower rate.
- The analysis of groundwater nitrate trends in the LUB GWMA well network suggest an upward trend in nitrate levels is occurring throughout most of the GWMA.

Food Processor Land Application Sites

- Most wells (54%) exhibited increasing trends while 20% of wells exhibited decreasing trends, 1% exhibited a flat trend, and 25% exhibited statistically insignificant trends.
- Evidence of elevated and increasing nitrate concentrations include:
  - The site-wide trend is increasing at eight sites , decreasing at two sites, statistically insignificant at one site, and flat at one site, and
  - The site-wide average nitrate concentration is above the 7 mg/l GWMA trigger level at 10 of 12 sites.
- Evidence that nitrate concentrations are improving since 2005 include:
  - There are fewer sites with an increasing trend and more sites with decreasing trends. The site-wide trend is increasing at five sites, decreasing at four sites, and statistically insignificant at 3 sites.
  - Eight of the 12 sites show improving site-wide nitrate trends (i.e., increasing less steeply than before), and
  - Four of the 12 sites show lower site-wide average nitrate concentrations than before.
- While nitrate concentrations are increasing at most wells and at most sites, and average nitrate concentrations at most sites exceed the GWMA trigger level, the rate of increase is slower than it was during the previous analysis.
- The reduction in the percentage of increasing trends coupled with the rise in the percentage of decreasing trends illustrates that improvements in groundwater quality are occurring in some areas.
- The fact that over twice as many wells still show increasing trends than show decreasing trends illustrates that more time and perhaps more changes in land application practices will be required to achieve the goal of an area-wide decreasing nitrate trend.
- The analysis of groundwater nitrate trends at the food processor land application sites suggest an upward trend in nitrate levels is occurring throughout most of the GWMA.

Three Mile Canyon Farms

- One-third of the 15 wells exhibited increasing trends, 27% exhibited decreasing trends, and 40% exhibited statistically insignificant trends.
- Increasing and decreasing trends occur throughout the well network.
- There is no discernible pattern of increasing or decreasing trends at these 15 locations.

- Recent changes in nitrate trends are approximately equally split between those that showed an improving trend (i.e., increasing less steeply after 2005 than before 2005 or decreasing steeper after 2005 than before 2005) and those that showed a worsening trend (i.e., increasing steeper or decreasing less steeply).
- Thirteen of 15 wells exhibit nitrate concentrations greater than the 10 ppm drinking water standard.
- The two surface water locations sampled exhibit at least some degree of seasonality, statistically insignificant trends, and average nitrate concentrations above the 10 ppm drinking water standard.
- The analysis of the 15 TMCF wells suggests a downward trend in nitrate levels may be occurring at the site.

Public Supply Wells

- There are 59 public water supply systems within the LUB GWMA serving 39,554 people.
- Five of these systems (serving 437 people) require treatment for nitrate.
- In addition to the five systems with treatment, two systems (serving 1,800 people) drilled new wells because of nitrate contamination.
- Proper well construction (e.g., an adequate seal above the well screen) is important to minimize the potential for contaminated water to move from one aquifer to another.
- Three of 59 public water supply systems had enough untreated nitrate data to perform a trend analysis.
    - Two of three wells analyzed exhibited statistically significant increasing trends. The third well showed a statistically insignificant trend.
    - Nitrate concentrations at these wells range from 0.17 ppm to 12.9 ppm.
- Both public supply wells with data after 2005 show a slight improvement in nitrate trend in recent years (i.e., they are increasing less steeply after 2005 than before 2005).
- One of these wells exhibited concentrations above the 10 ppm drinking water standard until treatment was installed.
- The analysis of groundwater nitrate trends at three public supply wells do not suggest a downward trend in nitrate levels is occurring throughout most of the GWMA.

Synoptic Sampling Events

- 58% of the wells sampled in the third synoptic sampling event exhibited nitrate concentrations greater than the 7 mg/l GWMA trigger level.
- The median, average, and maximum nitrate concentrations of wells sampled in both events were higher in the third event than in the first event.
- Of the 98 wells sampled in both the first and third events, 54% showed a significant increase, 24% showed a significant decrease, and 22% showed no significant change in nitrate concentration.
- There does not seem to be a systematic geographic correlation with changes in nitrate concentration.
- Monitoring wells generally exhibit higher nitrate concentrations than domestic wells of similar depth.
- The comparison of groundwater nitrate concentrations between the first and third synoptic sampling events do not suggest a downward trend in nitrate levels is occurring throughout most of the GWMA.

Depot Landfill Wells

- Nitrate concentrations at the tested Depot landfill wells range from 1.8 ppm 17 ppm.
- Average nitrate concentrations at these five wells range from 10.8 ppm to 14.5 ppm.
- 80% of the wells (4 of 5) exhibited decreasing trends, and 20% (one well) exhibited a statistically insignificant trend. No wells exhibited an increasing trend.
- Recent changes in nitrate trends generally show improving trends (i.e., they are increasing less steeply after 2005 than before 2005.).
- The site-wide trend from 1988 through 2010 is decreasing at 0.1 ppm/yr.
- The LOWESS line through all the data increases slightly in the early 1990s but then decreases through 2010.

- The analysis of nitrate concentrations at the Depot landfill indicates a decreasing nitrate trend is evident 14 years after the landfill was closed and capped.

Real Estate Transaction Database

- Nitrate concentrations exceeded the 7 mg/l GWMA trigger level in 18% of the results.
- Nitrate concentrations exceeded the 10 mg/l drinking water standard in 10% of the results.
- Nitrate concentrations were less than 1 mg/l (suggesting no influence from human activities) in 38% of the wells.
- Analysis of nitrate concentrations from the real estate transaction database confirmed the presence of elevated nitrate concentrations in the LUB GWMA but did not suggest anything about nitrate trends in the alluvial aquifer.

GWMA-Wide

- At least 40% (likely closer to 50%) of approximately 650 wells tested have an average nitrate concentration greater than the 7 mg/l GWMA trigger level.
- Of the 201 wells analyzed for a nitrate trend, about half show increasing trends, one-quarter show decreasing trends, and one-quarter show statistically insignificant trends.
- The proportions of increasing, decreasing, and statistically insignificant trends within the regularly sampled LUB GWMA network of 32 wells are very similar to the proportions of all 201 wells tested, as well as the comparison of the 98 synoptic sampling event wells. This similarity suggests the network provides a reasonable representation of the GWMA as a whole.
- The LUB GWMA Action Plan measure of success that calls for decreasing nitrate concentrations throughout the GWMA by the end of 2009 was not met.

11.2 Recommendations

Based on the above conclusions, the following recommendations are made.

- The LUB GWMA Committee and sub-committees should consider this report when drafting the next Four-Year Evaluation of Action Plan Success.
- The LUB GWMA Committee and sub-committees should consider this report when drafting the next LUB GWMA Action Plan.

12.0 References

Cleveland, W.S., 1979, Robust Locally Weighted Regression and Smoothing Scatterplots: *J. Am. Stat. Assoc. 74*, 829-836.

DEQ, 2006. 2003 Lower Umatilla Basin Groundwater Management Area Synoptic Sampling Event Report.

DEQ, 2007. Second Trend Analysis of Food Processor Land Application Sites in the Lower Umatilla Basin Groundwater Management Area.

DEQ, 2011. Third Trend Analysis of Food Processor Land Application Sites in the Lower Umatilla Basin Groundwater Management Area.

EPA, 2006. Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S, EPA/240/B-06/003. 190 pgs.

Helsel, D.R., 2005. Nondetects and Data Analysis: Statistics for Censored Environmental Data. John Wiley & Sons, Inc., Hoboken, New Jersey. 250 pg.

Helsel, D.R., and L.M. Frans, 2006. Regional Kendall Test For Trend, *Environmental Science & Technology, Vol. 40, No. 13,* pg 4066-4073.

Table 3-1
Individual Well Nitrate Trends - LUB GWMA Well Network
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Minimum	Maximum	Mean	Median	n	% BDL	Slope (ppm/yr)	Confidence Level		
UMA033	Oct-91	Nov-09	5.9	13.8	7.38	6.98	111	0%	-0.006	41%	NS80	Decrease then flat
UMA034	Oct-91	Nov-09	1.12	7.37	3.56	3.4	108	0%	0.01	66%	NS80	Increase, decrease, increase
UMA038	Oct-91	Nov-09	0.98	9.68	3.08	3.0	99	0%	-0.09	99%	Decreasing	Increase then decrease
UMA039	Oct-91	Sep-04	0.2	5.67	2.94	2.96	64	0%	0.27	99%	Increasing	Increasing
UMA046	Oct-91	Nov-09	0.25	3.5	0.77	0.6	105	0%	-0.03	99%	Decreasing	Decreasing
UMA048	Oct-91	Nov-09	1.20	2.22	1.79	1.8	107	0%	0.01	99%	Increasing	Increase then decrease
UMA056	Oct-91	Nov-09	0.58	7.32	6.27	6.4	107	0%	-0.07	99%	Decreasing	Decreasing
UMA058	Oct-91	Nov-04	7.08	30	13.1	11.2	74	0%	-0.61	99%	Decreasing	Increase then decrease
UMA066	Oct-91	Sep-02	4.80	9.4	7.55	7.6	64	0%	0.24	99%	Increasing	Increase, increase steeper, level off
UMA084	Oct-91	Nov-09	3.35	22	11.0	10.96	96	0%	-0.11	95%	Decreasing	Increase, decrease, increase
UMA085	Oct-91	Jul-07	20	46.3	32.4	31.0	83	0%	1.46	99%	Increasing	Increasing
UMA088	Oct-91	Nov-02	11	21	15.3	15.3	64	0%	0.40	99%	Increasing	Increase, level off, increase
UMA094	Oct-91	Nov-09	4.24	13	8.91	8.5	108	0%	0.04	60%	NS80	Decrease then increase
UMA096	Oct-91	Nov-09	12.8	40.5	29.9	30.75	106	0%	0.20	99%	Increasing	Flat then increase
UMA103	Oct-91	Nov-09	8.5	30.5	21.2	21.0	98	0%	0.25	99%	Increasing	Decrease, increase, level off
UMA109	Oct-91	Nov-09	1.3	6.43	3.56	3.56	105	0%	0.09	99%	Increasing	Increase then decrease
UMA110	Oct-91	Nov-09	1.89	27.9	6.85	5.500	107	0%	-0.01	17%	NS80	Increase, decrease, increase
UMA112	Oct-91	Nov-09	1.31	5.8	3.17	3.10	108	0%	-0.16	99%	Decreasing	Decrease, increase, decrease
UMA116	Oct-91	Nov-09	2.3	5.12	3.87	3.88	107	0%	0.03	99%	Increasing	Increase then decrease
UMA119	Oct-91	Nov-09	3.5	22.4	12.9	13.7	105	0%	0.27	99%	Increasing	Increase then level off
UMA122	Oct-91	Sep-05	6.9	34.4	20.5	21.0	77	0%	1.56	99%	Increasing	Increase, then increase steeper
UMA133	Oct-91	Nov-09	1.8	35	19.4	17.3	103	0%	-0.36	99%	Decreasing	Increase then decrease
UMA144	Oct-91	Nov-09	1.46	42.3	13.9	13	107	0%	-0.08	76%	NS80	Decrease then increase
UMA156	Oct-91	Nov-09	7.76	36.3	19.4	18.4	102	0%	0.31	99%	Increasing	Increase, decrease, increase
UMA160	Oct-91	Nov-09	<0.0050	27.5	4.31	0.05	103	22%	0.61	99%	Increasing	Flat then increase
UMA168	Oct-91	Nov-09	1.24	5.8	3.45	3.50	107	0%	-0.08	99%	Decreasing	Decrease, increase, decrease
UMA180	Oct-91	Nov-09	<0.02	12.7	4.55	4.09	84	1%	0.54	99%	Increasing	Increase, then increase steeper
UMA185	Oct-91	Nov-09	0.006	0.164	0.14	0.14	99	0%	0.001	99%	Increasing	Slight increase
UMA187	Oct-91	Nov-09	<0.0050	0.134	0.01	<0.02	99	90%	0	nc	Flat	Flat
UMA190	Oct-91	Nov-09	0.53	11	2.42	2.00	101	0%	0.054	99%	Increasing	Increase then decrease
UMA191	Oct-91	Nov-09	0.16	6.11	0.98	0.869	106	0%	0.002	22%	NS80	Increase then decrease
UMA198	Oct-91	Nov-09	2.70	46.4	18.1	16	101	0%	0.62	99%	Increasing	Increasing
UMA201	Oct-91	Nov-09	7.40	32.5	19.1	19.5	107	0%	0.94	99%	Increasing	Increasing
UMA028	Oct-91	Nov-08	1.9	13	3.1	5.8	91	0%	0.30	99%	Increasing	Increase then decrease
UMA029	Oct-91	Nov-09	25.0	64	45.1	46.3	101	0%	-0.04	29%	NS80	Flat then decrease
UMA047	Oct-91	Nov-09	2.5	3.86	3.18	3.19	104	0%	0.07	99%	Increasing	Increasing
UMA106	Oct-91	Nov-09	0.42	2.02	0.90	0.8355	100	0%	0.001	9%	NS80	Flat then decrease
UMA164	Oct-91	Nov-09	<0.02	5.35	3.75	4.14	101	1%	0.15	99%	Increasing	Increasing

Notes:

nc = not calculated

n = number of samples

BDL = below detection limit

NS80 = not significant at an 80% confidence level

[shaded] = well no longer sampled.

	All 38 Wells	31 Currently Sampled Wells
# of Increasing Trends ==>	21 (55%)	15 (48%)
# of Decreasing Trends ==>	8 (21%)	7 (23%)
# of Flat Trends ==>	1 (3%)	1 (3%)
# of Insignificant Trends ==>	8 (21%)	8 (26%)
Avg slope of significant trends at the wells ==>	0.23	0.14
Avg slope of all trends at the wells ==>	0.18	0.10

E:\LUB\2011 Analysis of GW NO3 Conc in LUB GWMA\Figures\[All Trends - bimonthly wells.xlsx]Summary Table 38 wells since 91

Table 3-2
Recent Changes in Individual Well Nitrate Trends - LUB GWMA Well Network
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Sample Location	1991 through 2005 Trend Analysis Results			1991 through 2009 Trend Analysis Results			Difference in Slope	Change From 2005 to 2009
	Slope (ppm/yr)	Confidence Level	Trend Direction	Slope (ppm/yr)	Confidence Level	Trend Direction		
UMA033	-0.008	46%	NS80	-0.006	41%	NS80	0.002	Worsened
UMA034	0.004	7%	NS80	0.014	66%	NS80	0.011	Worsened
UMA038	-0.07	98%	Decreasing	-0.09	99%	Decreasing	-0.025	Improved
UMA039								
UMA046	-0.03	99%	Decreasing	-0.03	99%	Decreasing	0.000	No Change
UMA048	0.03	99%	Increasing	0.01	99%	Increasing	-0.015	Improved
UMA056	-0.06	99%	Decreasing	-0.07	99%	Decreasing	-0.009	Improved
UMA058								
UMA066								
UMA084	-0.29	99%	Decreasing	-0.11	95%	Decreasing	0.181	Worsened
UMA085								
UMA088								
UMA094	0.04	60%	NS80	0.04	60%	NS80	0.000	No Change
UMA096	-0.07	74%	NS80	0.20	99%	Increasing	0.275	Worsened
UMA103	0.25	99%	Increasing	0.25	99%	Increasing	0.000	No Change
UMA109	0.09	99%	Increasing	0.09	99%	Increasing	0.000	No Change
UMA110	-0.21	99%	Decreasing	-0.01	17%	NS80	0.202	Worsened
UMA112	-0.16	99%	Decreasing	-0.16	99%	Decreasing	0.000	No Change
UMA116	0.10	99%	Increasing	0.03	99%	Increasing	-0.065	Improved
UMA119	0.27	99%	Increasing	0.27	99%	Increasing	0.000	No Change
UMA122								
UMA133	-0.38	99%	Decreasing	-0.36	99%	Decreasing	0.024	Worsened
UMA144	-0.27	98%	Decreasing	-0.08	76%	NS80	0.181	Worsened
UMA156	0.25	93%	Increasing	0.31	99%	Increasing	0.069	Worsened
UMA160	0.61	99%	Increasing	0.61	99%	Increasing	0.000	No Change
UMA168	-0.08	99%	Decreasing	-0.08	99%	Decreasing	0.000	No Change
UMA180	0.35	99%	Increasing	0.54	99%	Increasing	0.195	Worsened
UMA185	0.001	99%	Increasing	0.001	99%	Increasing	0.000	No Change
UMA187	-0.002	91%	Decreasing	0	nc	Flat	0.002	Worsened
UMA190	0.054	99%	Increasing	0.054	99%	Increasing	0.000	No Change
UMA191	0.02	94%	Increasing	0.002	22%	NS80	-0.021	Improved
UMA198	0.68	99%	Increasing	0.62	99%	Increasing	-0.056	Improved
UMA201	0.94	99%	Increasing	0.94	99%	Increasing	0.000	No Change
UMA028								
UMA029	0.50	99%	Increasing	-0.04	29%	NS80	-0.536	Improved
UMA047	0.071	99%	Increasing	0.067	99%	Increasing	-0.004	Improved
UMA106	0.006	62%	Increasing	0.001	9%	NS80	-0.005	Improved
UMA164	0.16	99%	Increasing	0.15	99%	Increasing	-0.010	Improved

Summary of Changes				
# Wells	Change	Average Change	Median Change	Maximum Change
10 wells	Worsened	0.11 ppm/yr	0.12 ppm/yr	0.28 ppm/yr
10 wells	Improved	0.07 ppm/yr	0.02 ppm/yr	0.54 ppm/yr
11 wells	Showed No Change			

= well no longer sampled (7 wells)

= confidence level changed enough to change statistical significance (7 wells)

= slope changed direction (1 well)

NS80 = not statistically significant at an 80% confidence level

E:\LUB\2011 Analysis of GW NO3 Conc in LUB GWMA\[All Trends - bimonthly wells.xlsx]Table 3-2

Table 4-1
Summary of Nitrate Trends and Average Concentrations by Site
Analysis of Groundwater Nitrate Concentrations in the LUBGWMA

		From Well Installation Through 2009 (variable lengths of time)											*From 2005 through 2009*		
Site	***# of Wells***	***Increasing Trends***		***Decreasing Trends***		***Flat Trends***		***Statistically Insignificant Trends***		***Site-Wide Trend***		***Site-Wide Average Concentration (ppm)***	***Site-Wide Trend***		***Site-Wide Average Concentration (ppm)***
		#	***%***	***#***	***%***	***#***	***%***	***#***	***%***	***slope (ppm/yr)***	***C.L.***		***slope (ppm/yr)***	***C.L.***	
Port of Morrow (Farm 1)	12	6	50%	2	17%	0	0%	4	33%	0.41	99%	23.3	-0.69	99%	27.1
Port of Morrow (Farm 2)	10	5	50%	1	10%	0	0%	4	40%	0.79	<80%	36.6	0.20	<80%	35.3
Port of Morrow (Farm 3)	6	4	67%	1	17%	0	0%	1	17%	2.29	99%	37.5	1.17	98%	41.1
ConAgra (North Farm)	13	7	54%	2	15%	0	0%	4	31%	0.11	99%	27.2	0.32	99%	29.9
ConAgra (Madison Ranches)	13	9	69%	1	8%	0	0%	3	23%	0.09	99%	5.7	0.13	99%	6.3
Simplot (Plant Site)	11	4	36%	3	27%	0	0%	4	36%	0.00	97%	9.3	-0.21	92%	8.3
Simplot (Expansion Site)	12	9	75%	1	8%	0	0%	2	17%	0.19	99%	9.1	0.10	88%	10.4
Simplot (Terrace Site)	8	5	63%	2	25%	0	0%	1	13%	0.63	99%	27.1	0.20	<80%	29.2
Simplot (Levy Site)	9	3	33%	1	11%	1	11%	4	44%	0.30	99%	15.7	0.25	99%	16.1
Hermiston Foods	7	3	43%	4	57%	0	0%	0	0%	-0.06	99%	7.4	0.05	<80%	7.3
MorStarch Site	8	5	63%	2	25%	0	0%	1	13%	0.03	99%	4.1	-0.09	99%	4.1
Snack Alliance	4	1	25%	3	75%	0	0%	0	0%	-0.21	99%	8.9	-0.21	82%	7.1
Totals by Well	***113***	***61***	***54%***	***23***	***20%***	1	1%	***28***	***25%***						

Steepest Decreasing Trend At A Well = *-2.97 ppm/yr*
Steepest Increasing Trend At A Well = *19.7 ppm/yr*

In addition to the 113 wells indicated above, two former ConAgra Madison Ranch wells (now considered offsite) were also analyzed. Results indicated 2 decreasing trends.
In addition to the 113 wells indicated above, one well at the Port of Morrow Farm 3 site does not yet have enough data to evaluate a trend.
The site-wide trends were calculated using the Regional Kendall Method.
Because this comparison uses information from all onsite wells regardless of how long they were sampled, some values differ from those in Table 4-2.

Table 4-2
Comparison of Results From Wells Analyzed Three Times
Analysis of Groundwater Nitrate Concentrations in the LUBGWMA

Site	*# Wells*	*# of Increasing Trends*				*# of Decreasing Trends*				*# of Flat Trends*				*# of Statistically Insignificant Trends*				*Average trend slope (ppm/yr)*				*Average of average Nitrate Concentration at Each Well (ppm)*			
		thru 2001	*thru 2005*	*thru 2009*	*2005 to 2009 Change*	*thru 2001*	*thru 2005*	*thru 2009*	*2005 to 2009 Change*	*thru 2001*	*thru 2005*	*thru 2009*	*2005 to 2009 Change*	*thru 2001*	*thru 2005*	*thru 2009*	*2005 to 2009 Change*	*thru 2001*	*thru 2005*	*thru 2009*	*2005 to 2009 Change*	*thru 2001*	*thru 2005*	*thru 2009*	*2005 to 2009 Change*
Port of Morrow (Farm 1)	11	8	8	6	-2	0	2	2	0	0	0	0	0	3	1	3	2	1.63	0.71	0.47	-0.24	26.2	27.1	27.2	0.1
Port of Morrow (Farm 2)	9	9	7	5	-2	0	0	1	1	0	0	0	0	0	2	3	1	2.51	1.43	0.63	-0.80	33.6	34.5	35.2	0.7
Port of Morrow (Farm 3)	6	--	3	4	1	--	2	1	-1	--	0	0	0	--	1	1	0	--	2.86	2.36	-0.50	--	33.0	37.8	4.8
ConAgra (North Farm)	10	5	5	5	0	2	2	2	0	0	0	0	0	3	3	3	0	1.29	0.72	0.35	-0.37	24.2	25.1	25.3	0.2
ConAgra (Madison Ranch)	9	7	7	6	-1	0	1	1	0	0	0	0	0	2	1	2	1	0.65	0.28	0.25	-0.03	4.7	5.3	5.8	0.5
Simplot (Plant Site)	11	1	2	4	2	1	3	3	0	1	0	0	0	8	6	4	-2	0.46	-0.47	-0.38	0.09	10.8	10.3	10.1	-0.2
Simplot (Expansion Site)	12	11	11	9	-2	0	0	1	1	0	0	0	0	1	1	2	1	0.65	0.34	0.27	-0.07	8.4	8.8	9.2	0.4
Simplot (Terrace Site)	8	7	5	5	0	0	1	2	1	0	0	0	0	1	2	1	-1	1.62	0.62	0.39	-0.23	25.4	25.8	26.3	0.5
Simplot (Levy Site)	9	--	4	3	-1	--	0	1	1	--	0	1	1	--	5	4	-1	--	1.97	1.24	-0.73	--	14.4	15.5	1.1
Hermiston Foods	6	2	2	2	0	0	4	4	0	0	0	0	0	4	0	0	0	0.29	-0.08	-0.05	0.03	7.9	7.6	7.5	-0.1
MorStarch Site	8	8	6	5	-1	0	1	2	1	0	0	0	0	0	1	1	0	0.44	0.18	0.10	-0.08	4.2	4.2	4.2	0.0
Snack Alliance	4	0	0	0	0	1	3	3	0	0	0	0	0	3	1	1	0	-0.64	-0.57	-0.57	0.00	10.3	10.4	9.2	-1.2
Total	***103***	***58***	***60***	***54***	***-6***	***4***	***19***	***23***	***4***	***1***	0	***1***	***1***	***25***	***24***	***25***	***1***								
Percentage		***66%***	***58%***	***52%***	***-6%***	***5%***	***18%***	***22%***	***4%***	***1%***	0%	***1%***	***1%***	***28%***	***23%***	***24%***	***1%***								

Summary		
Item	***Result of Analysis through 2009***	***Difference Between Second and Third Analyses***
Number of Increasing and Decreasing Trends	54 increasing trends; 23 decreasing trends	6% fewer increasing trends; 4% more decreasing trends
Average Trend Slope at 12 Sites	Increasing at 9 sites; decreasing at 3 sites	Improved at 9 sites; worsened at 2 sites; no change at 1 site
Average of average nitrate concentration at each well	Exceeded 7 ppm GWMA trigger level at 10 of 12 sites	Improved at 3 sites; worsened at 8 sites; no change at 1 site

Notes:
Because this comparison uses information only from the onsite wells analyzed each time (i.e, 88 wells in 2001, 103 wells in 2005 and 2009), some values differ from those in other tables in this document.
The average trend slope is the average of statistically significant trends only.
The average of the average nitrate concentration at each well uses all onsite wells currently being sampled.

Table 5-1
Individual Well Nitrate Trends - Threemile Canyon Farms
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	Are the Data Seasonal ?	LOWESS Pattern
	Starting Date	Ending Date	Minimum	Maximum	Mean	Median	n	% BDL	Slope (ppm/yr)	Confidence Level			
RDOU-1	Sep-00	Sep-09	26.7	50.1	37.3	38.0	31	0%	0.83	90%	Increasing	No	Decrease then Increase
RDOU-2	Sep-00	Mar-06	29.5	53.2	26.4	34.1	20	0%	-1.35	35%	No Significant Trend	No	Decrease then Increase
RDOU-3A	Jun-02	Sep-09	20.6	33.8	28.3	28.0	26	0%	0.80	91%	Increasing	No	Increase then Decrease
Simplot MW-7	Dec-02	Sep-09	48.5	100.5	78.3	81.1	24	0%	-2.83	88%	Decreasing	No	Increase then Decrease
CWU-1	Jun-00	Jun-04	27.6	77	39.0	37.4	13	0%	-3.31	77%	No Significant Trend	No	Decrease then Increase
CWU-1A	Mar-04	Sep-09	20	41.6	28.6	28.1	14	0%	4.19	99%	Increasing	No	Increasing
CWU-2	Jun-00	Sep-09	2.58	90.7	28.8	15.9	31	0%	-8.76	99%	Decreasing	No	Decreasing
CWU-3	Aug-00	Sep-09	0.59	63.9	10.6	9.2	30	0%	0.30	99%	Increasing	No	Increasing
CWU-4	Jun-02	Sep-09	16.8	32.55	21.9	21.8	25	0%	1.04	99%	Increasing	No	Increasing
CWU-5	Jun-02	Sep-09	8	21	9.9	9.6	26	0%	0.03	19%	No Significant Trend	No	Increase then Decrease
SU-1	Jun-00	Sep-09	2.82	7.9	4.0	3.7	31	0%	-0.08	90%	Decreasing	No	Decrease then Increase
SU-2	Jun-00	Jun-03	29.8	52.9	38.6	36.7	4	0%	-0.11	0%	No Significant Trend	No	Increase then Decrease
SU-3	Sep-00	Sep-09	11	43.4	16.1	13.7	30	0%	-0.24	78%	No Significant Trend	No	Decreasing
SU-4A	Jun-02	Sep-09	30	69.8	53.5	51.9	24	0%	0.02	0%	No Significant Trend	No	Increase then Decrease
HRF-1	Mar-05	Sep-09	38	53.5	47.9	49.3	13	0%	-1.84	95%	Decreasing	No	Decreasing
Sixmile Canyon Pump 2	*Aug-00*	*Jun-04*	*2.1*	*30.9*	*14.4*	*13.1*	*15*	*0%*	*-1.57*	*73%*	*No Significant Trend*	*Yes*	*Decrease then Increase*
Office Pond	*Mar-02*	*Sep-08*	*18*	*42.2*	*27.7*	*27.2*	*24*	*0%*	*0.84*	*75%*	*No Significant Trend*	*No*	*Flat, Increase, then Decrease*

# of Increasing Trends ==>	5
# of Decreasing Trends ==>	4
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	6
Average slope of significant trends (ppm/yr) ==>	-0.70
Average slope of all trends (ppm/yr) ==>	-0.75

Note: Some wells were sampled monthly at first then quarterly then semiannually. The data sets were trimmed to quarterly samples so as to not overly weight early data.

E:\LUB\Threemile Canyon Farms\[TMCFwq.xlsx]Summary

Table 5-2
Recent Changes in Individual Well Nitrate Trends - Threemile Canyon Farms
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Sample Location	Starting Date	Ending Date	2000 through 2005 Trend Analysis Results			2000 through 2009 Trend Analysis Results			Difference in Slope	Change From 2005 to 2009
			Slope (ppm/yr)	Confidence Level	Trend Direction	Slope (ppm/yr)	Confidence Level	Trend Direction		
RDOU-1	Sep-00	Sep-09	0.05	0%	No Significant Trend	0.83	90%	Increasing	-0.77	Worsened
RDOU-2	Sep-00	Mar-06	-2.02	61%	No Significant Trend	-1.35	35%	No Significant Trend	-0.68	Worsened
RDOU-3A	Jun-02	Sep-09	2.60	99%	Increasing	0.80	91%	Increasing	1.80	Improved
Simplot MW-7	Dec-02	Sep-09	8.90	82%	Increasing	-2.83	88%	Decreasing	11.73	Improved
CWU-1	Jun-00	Jun-04	No Trend (No data points after 2004)			-3.31	77%	No Significant Trend		
CWU-1A	Mar-04	Sep-09	No Trend (Only 4 data points through 2005)			4.19	99%	Increasing		
CWU-2	Jun-00	Sep-09	-15.26	99%	Decreasing	-8.76	99%	Decreasing	-6.50	Worsened
CWU-3	Aug-00	Sep-09	0.12	30%	No Significant Trend	0.30	99%	Increasing	-0.18	Worsened
CWU-4	Jun-02	Sep-09	1.70	99%	Increasing	1.04	99%	Increasing	0.66	Improved
CWU-5	Jun-02	Sep-09	0.13	54%	No Significant Trend	0.03	19%	No Significant Trend	0.10	Improved
SU-1	Jun-00	Sep-09	-0.21	89%	Decreasing	-0.08	90%	Decreasing	-0.13	Worsened
SU-2	Jun-00	Jun-03	No Trend (No data points after 2003)			-0.11	0%	No Significant Trend		
SU-3	Sep-00	Sep-09	-1.30	93%	Decreasing	-0.24	78%	No Significant Trend	-1.07	Worsened
SU-4A	Jun-02	Sep-09	4.85	98%	Increasing	0.02	0%	No Significant Trend	4.83	Improved
HRF-1	Mar-05	Sep-09	No Trend (Only 3 data points through 2005)			-1.84	95%	Decreasing		
Sixmile Canyon Pump 2	*Aug-00*	*Jun-04*	No Trend (No data points after 2004)			*-1.57*	*73%*	*No Significant Trend*		
Office Pond	*Mar-02*	*Sep-08*	*1.95*	*16%*	*No Significant Trend*	*0.84*	*75%*	*No Significant Trend*	*1.11*	*Improved*

Summary of Changes				
# Wells	Change	Average Change	Median Change	Maximum Change
6 wells	Worsened	1.55 ppm/yr	0.73 ppm/yr	6.5 ppm/yr
5 wells	Improved	3.82 ppm/yr	1.8 ppm/yr	11.7 ppm/yr

= No trend calculated due to lack of data (4 wells)

= confidence level changed enough to change statistical significance (4 wells)

= slope changed direction (1 well)

Note: Some wells were sampled monthly at first then quarterly then semiannually. The data sets were trimmed to quarterly samples so as to not overly weight early data.

E:\LUB\Threemile Canyon Farms\[TMCFwq.xlsx]Table 5-2

Table 6-1
Public Water Supply Systems Within the LUB GWMA
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

PWSID	PWSName	Population	Connections	SystemType	State	City	Zip	PrimarySource	CountyServed
95280	ALIVE AND WELL	50	1	NC	HERMISTON	OR	97838	GW	Umatilla
95236	BELLINGER PRODUCE LLC	25	2	NC	HERMISTON	OR	97838	GW	Umatilla
130	BOARDMAN, CITY OF	3330	786	C	BOARDMAN	OR	97818	GW	Morrow
5884	CASCADE SPECIALTIES INC	40	1	NTNC	BOARDMAN	OR	97818	GW	Morrow
371	CHARLES TRACTS WATER COMPANY	240	68	C	HERMISTON	OR	97838	GW	Umatilla
1415	CHART SUBDIVISION	125	38	C	HERMISTON	OR	97838	GW	Umatilla
90178	COE MCNARY DAM	120	7	NTNC	UMATILLA	OR	97882	GW	Umatilla
95174	COLUMBIA RIVER DAIRY	50	2	NTNC	BOARDMAN	OR	97818	GW	Morrow
95314	COMFORT INN & SUITES-HERMISTON	100	1	NC	HERMISTON	OR	97838	GW	Umatilla
94562	CONAGRA LAMB WESTON	500	1	NTNC	HERMISTON	OR	97838	GW	Umatilla
1182	***COUNTRY GARDEN ESTATES MHP***	***110***	***35***	***C***	***IRRIGON***	***OR***	***97844***	***GW***	***Morrow***
1045	COUNTRY SQUIRE ESTATES	85	55	C	HERMISTON	OR	97838	GW	Umatilla
1044	DUN-ROLLIN MOBILE HOME PARK	130	103	C	HERMISTON	OR	97838	GW	Umatilla
270	ECHO, CITY OF	715	260	C	ECHO	OR	97826	GW	Umatilla
95207	EXPRESS MARTS	60	2	NC	HERMISTON	OR	97838	GW	Umatilla
622	FRONTIER MOBILE HOME PARK	10	4	NP	SALEM	OR	97301-4515	GW	Umatilla
95168	GREEN ACRES	40	62	NC	IRRIGON	OR	97844	GW	Morrow
91232	HAT ROCK MOBILE COURT	60	28	C	HERMISTON	OR	97838	GW	Umatilla
91072	OPRD HAT ROCK STATE PARK	500	6	NC	MEACHAM	OR	97859	GW	Umatilla
1309	HAT ROCK WATER COMPANY	75	38	C	HERMISTON	OR	97838	GW	Umatilla
95106	HERMISTON 1	300	1	NC	PORTLAND	OR	97296	GW	Umatilla
95145	HERMISTON 2	150	1	NC	PORTLAND	OR	97296	GW	Umatilla
95066	HERMISTON JUNIOR ACADEMY	65	1	NTNC	HERMISTON	OR	97838	GW	Umatilla
6171	HERMISTON NAZARENE CHURCH	20	1	NP	HERMISTON	OR	97838	GW	Umatilla
372	***HERMISTON, CITY OF***	***15410***	***4400***	***C***	***HERMISTON***	***OR***	***97838***	***SW***	***Umatilla***
5815	HERRERAS PARK	20	7	NP	BOARDMAN	OR	97818	GW	Morrow
403	IRRIGON, CITY OF	1740	620	C	IRRIGON	OR	97844	GW	Morrow
94561	JR SIMPLOT/CALPINE	22	2	NP	HERMISTON	OR	97838	GW	Umatilla
374	NORTH HILL WATER CORPORATION	100	28	C	HERMISTON	OR	97838	GW	Umatilla
5683	ODF/WL IRRIGON FISH HATCHERY	18	8	NP	IRRIGON	OR	97844	GW	Morrow
5906	ODF/WL UMATILLA HATCHERY	12	5	NP	IRRIGON	OR	97844	GW	Morrow
93659	ODOT BOARDMAN REST AREA	999	2	NC	SALEM	OR	97302	GW	Morrow
91122	ODOT HD STANFIELD REST AREA	200	4	NC	HERMISTON	OR	97838	GW	Umatilla
93656	OPRD DEADMANS PASS REST AREA	500	4	NC	HERMISTON	OR	97838	GW	Umatilla
6156	OSU HERMISTON AG REC	20	10	NP	HERMISTON	OR	97838	GW	Umatilla
90513	PGE BOARDMAN COAL FIRE PLANT	100	1	NTNC	BOARDMAN	OR	97818	GW	Morrow
94726	PGG PUMP & IRRIGATION BLDG	24	3	NP	HERMISTON	OR	97838	GW	Umatilla
94982	PILOT TRAVEL CENTER-STANFIELD	950	2	NC	STANFIELD	OR	97875	GW	Umatilla
1328	PORT OF MORROW	1350	14	NTNC	BOARDMAN	OR	97818	GW	Morrow
375	POWER CITY WATER CO-OP	70	35	C	UMATILLA	OR	97882	GW	Umatilla
6074	PUNKIN CENTER MOBILE HOME PARK	24	14	NP	HERMISTON	OR	97838	GW	Umatilla
95213	RIVER POINT FARMS LLC	250	1	NTNC	HERMISTON	OR	97838	GW	Umatilla
5257	ROCKIN D RESIDENTIAL CARE	14	2	NP	HERMISTON	OR	97838	GW	Umatilla
5842	SAND BUR WATER ASSOCIATION	20	10	NP	UMATILLA	OR	97882	GW	Umatilla
1214	SHADY REST MOBILE COURT	90	57	C	UMATILLA	OR	97882	GW	Umatilla
95173	SHORT STOP #1	100	1	NC	HERMISTON	OR	97838	GW	Umatilla
91240	SPACE AGE FUEL	500	1	NC	HERMISTON	OR	97838	GW	Umatilla
1507	STANFIELD HUTTERIAN	10	5	NP	STANFIELD	OR	97875	GW	Umatilla
842	STANFIELD, CITY OF	2200	650	C	STANFIELD	OR	97875	GW	Umatilla
90873	UMATILLA MARINA	20	5	NP	UMATILLA	OR	97882	GW	Umatilla
914	UMATILLA, CITY OF	6495	1420	C	UMATILLA	OR	97882	GW	Umatilla
93426	UNION PACIFIC RR-HINKLE YARD	100	10	NTNC	HERMISTON	OR	97838	GW	Umatilla
95397	***UPPER COLUMBIA MILL***	***50***	***2***	***NTNC***	***BOARDMAN***	***OR***	***97818***	***GW***	***Morrow***
5955	UPS-HERMISTON	60	1	NTNC	PORTLAND	OR	97217	GW	Umatilla
1136	US ARMY DEPOT- UMATILLA ADMIN	170	25	NTNC	HERMISTON	OR	97838-9544	GW	Morrow
94664	US ARMY DEPOT- UMATILLA NORTH	662	10	NTNC	HERMISTON	OR	97838-9544	GW	Morrow
1099	VISTA HOME PARK	300	101	C	HERMISTON	OR	97838	GW	Umatilla
6201	WILDWOOD WATER	24	6	NP	HERMISTON	OR	97838	GW	Umatilla
95180	WILLOW CREEK DAIRY	30	7	NTNC	BOARDMAN	OR	97818	GW	Morrow
	59 Public Water Supply Systems	39,554							

5 Systems (shaded ones) have treatment for nitrate
3 Systems (***bold italic*** ones) have enough untreated data to evaluate.
2 Systems (hatched ones) drilled a new well due to nitrate contamination

City of Hermiston is almost all groundwater. The surface water goes to a food processor.

System Types:
C = Community
NC = Non-community
NP = non public (i.e., State-regulated)
NTNC = non-community, non-trantransient

Table 6-2
Nitrate Trends at Three Public Water Supply Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Minimum	Maximum	Mean	Median	n	% BDL	Slope (ppm/yr)	Confidence Level		
Country Garden Estates Mobile Home Park	Jun-84	Feb-10	0.17	9.8	5.1	5.4	15	0%	0.15	64%	Statistically Insignificant	Increase then Decrease
City of Hermiston Well #5 (trimmed to annual)	Nov-87	Aug-10	0.51	7	5.1	5.0	19	0%	0.10	90%	Increasing	Increasing
Upper Columbia Mill	Mar-08	Jan-11	5.59	12.9	10.6	11.0	13	0%	0.66	82%	Increasing	Increasing

# of Increasing Trends ==>	2
# of Decreasing Trends ==>	0
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	1
Average slope of significant trends (ppm/yr) ==>	0.38
Average slope of all trends (ppm/yr) ==>	0.30

Note: Some wells were not sampled on a consistent schedule. The data sets were trimmed to equally spaced samples so as to not overly weight more frequently sampled times.

E:\LUB\2010 LUBGWMA Trend Analysis\Public Supply Wells\[All Public Water Supply Systems.xlsx]Summary

Table 6-3
Recent Changes in Nitrate Trends at Three Public Water Supply Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Sample Location	Data Set Statistics		Trend Analysis Through 2005 Results			Trend Analysis Through 2010 Results			Difference in Slope	Change from 2005 to 2010
	Starting Date	Ending Date	Slope (ppm/yr)	Confidence Level	Trend Direction	Slope (ppm/yr)	Confidence Level	Trend Direction		
Country Garden Estates Mobile Home Park	Jun-84	Feb-10	0.17	83%	Increasing	0.15	64%	NS80	-0.03	Improved
City of Hermiston Well #5 (trimmed to annual)	Nov-87	Aug-10	0.12	56%	NS 80	0.10	90%	Increasing	-0.02	Improved
Upper Columbia Mill	Mar-08	Jan-11	no data prior to 2005			0.66	82%	Increasing		

Summary of Changes				
# Wells	Change	Average Change	Median Change	Maximum Change
2 wells	Improved	0.02 ppm/yr	0.02 ppm/yr	0.03 ppm/yr

= well not sampled prior to 2005 (1 well)

= confidence level changed enough to change statistical significance (2 wells)

NS80 = not statistically significant at an 80% confidence level

Note: Some wells were not sampled on a consistent schedule. The data sets were trimmed to equally spaced samples so as to not overly weight more frequently sampled times.

E:\LUB\2010 LUBGWMA Trend Analysis\Public Supply Wells\[All Public Water Supply Systems.xlsx]Table 6-3

Table 7-1
Nitrate Concentrations from Third Synoptic Sampling Event
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Well ID	Date Sampled	Nitrate (mg/l)	GWMA Network Well	OWRD #	Aquifer	Basalt TD	Alluvial TD	Monitoring Well	Irrigation Well	Domestic Well	Industrial Well	Well Type	LASAR_ID
Depot_11-7	10/21/2009	12.60			A		165	1				monitoring	36099
Depot_MW33	10/19/2009	14.70			A		166	1				monitoring	26343
M&P DAIRY MW-1	1/7/2010	20.90		MORR 51113	A		97	1				monitoring	35961
POM Booster Well #2	9/10/2009	35.20			A				1			irrigation	35959
Simplot HL-3	1/12/2010	8.54			A		49.37	1				monitoring	35955
Simplot HL-4	1/12/2010	10.20			A		30.95	1				monitoring	35957
Simplot HL-5	1/6/2010	54.10			A		29.75	1				monitoring	35956
Simplot L-11	1/6/2010	16.70			A		34.7	1				monitoring	35958
Simplot L-6	1/6/2010	2.13			A		45.45	1				monitoring	35954
UMA029	9/16/2009	32.30	1	MORR 873	B	100				1		domestic	16019
UMA033	9/15/2009	6.86	1	LUB 14	A		83			1		domestic	16023
UMA034	9/15/2009	3.79	1	MORR 1021	A		40			1		domestic	16024
UMA036	11/3/2009	0.63		MORR 1094	A		73			1		domestic	16026
UMA038	9/15/2009	1.66	1	UMAT 3374	A		66			1		domestic	16028
UMA041	9/16/2009	2.89		UMAT 2753	A		65			1		domestic	16031
UMA046	9/16/2009	0.41	1	UMAT 2863	A		110			1		domestic	16036
UMA047	9/15/2009	3.62	1	UMAT 2963	B	145				1		domestic	16037
UMA048	9/15/2009	1.97	1	UMAT 2953	A		85			1		domestic	16038
UMA056	9/16/2009	5.71	1	UMAT 2855	A		72			1		domestic	16046
UMA057	9/15/2009	14.30		UMAT 3405	A		69			1		domestic	16047
UMA065	9/15/2009	9.19		UMAT 3662	A		95			1		domestic	16055
UMA073	9/10/2009	5.93		UMAT 2424	A		70			1		domestic	16063
UMA079	9/9/2009	0.84		UMAT 2606	B?	150				1		domestic	16069
UMA080	11/4/2009	12.10		UMAT 2628	A		94			1		domestic	16070
UMA082	9/10/2009	<0.005		UMAT 2211	A		80			1		domestic	16072
UMA084	9/16/2009	14.00	1	UMAT 2453	A		80			1		domestic	16074
UMA086	9/10/2009	22.10		MORR 740	A		57			1		domestic	16076
UMA089	9/10/2009	4.68		UMAT 2448	A		60			1		domestic	16079
UMA094	9/15/2009	10.10	1		A		101			1		domestic	16084
UMA096	9/15/2009	35.90	1	UMAT 3271	A		57			1		domestic	16086
UMA103	9/15/2009	16.20	1	MORR 1431	A		40			1		domestic	16093
UMA106	9/16/2009	0.96	1	UMAT 2645	B	115				1		domestic	16096
UMA109	9/16/2009	4.14	1	UMAT 3727	A		45			1		domestic	16099
UMA110	9/16/2009	18.60	1	UMAT 2829	A		42			1		domestic	16100
UMA112	9/16/2009	1.42	1	MORR 630	A		185			1		domestic	16102
UMA116	9/16/2009	3.48	1	UMAT 3824	A		52			1		domestic	16106
UMA119	9/16/2009	8.74	1	UMAT 2305	A		40			1		domestic	16109
UMA123	9/15/2009	0.70		UMAT 2630	A		58			1		domestic	16113
UMA124	9/15/2009	18.00		UMAT 2525	A		107		1			irrigation	16114

Table 7-1
Nitrate Concentrations from Third Synoptic Sampling Event
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Well ID	Date Sampled	Nitrate (mg/l)	GWMA Network Well	OWRD #	Aquifer	Basalt TD	Alluvial TD	Monitoring Well	Irrigation Well	Domestic Well	Industrial Well	Well Type	LASAR_ID
UMA132	9/14/2009	18.80			?				1			irrigation	16122
UMA133	9/16/2009	13.60	1		A		80			1		domestic	16123
UMA136	9/14/2009	12.70		UMAT 1539	A		111			1		domestic	16126
UMA138	9/14/2009	0.23		UMAT 1867	B&A	135				1		domestic	16128
UMA144	9/15/2009	11.80	1	MORR 1178	A		57			1		domestic	16134
UMA156	9/16/2009	7.76	1	UMAT 2797	A		54			1		domestic	16146
UMA160	9/15/2009	5.18	1	MORR 1257	A		86		1			irrigation	16150
UMA161	10/21/2009	103.40		MORR 1250	A		133		1			irrigation	16151
UMA163	9/9/2009	0.27		MORR 1005	A		77			1		domestic	16153
UMA164	9/15/2009	4.91	1	MORR 1120	B	175				1		domestic	16154
UMA168	9/16/2009	2.02	1	MORR 946	A		173		1			irrigation	16158
UMA174	9/10/2009	44.20		MORR 1254	A		151		1			irrigation	16164
UMA177	9/9/2009	14.90		MORR 772	A		88		1			irrigation	16167
UMA180	9/15/2009	8.69	1	MORR 1325	A		47			1		domestic	16170
UMA185	9/16/2009	0.16	1	UMAT 1201	A		112			1		domestic	16175
UMA186	9/10/2009	4.48		UMAT 1168	A		330			1		domestic	16176
UMA187	9/16/2009	<0.005	1	UMAT 1169	A		100			1		domestic	16177
UMA190	9/15/2009	1.85	1	UMAT 1325	A		25			1		domestic	16180
UMA191	9/15/2009	0.71	1	UMAT 1274	A		22.5				1	industrial	16181
UMA192	9/9/2009	3.68		UMAT 1269	A		33		1			irrigation	16182
UMA198	9/15/2009	17.40	1	UMAT 1536	A		110	1				monitoring	16188
UMA201	9/15/2009	30.60	1	MORR 1469	A		85			1		domestic	16191
UMA208	10/22/2009	16.60			A		167	1				monitoring	16198
UMA218	1/13/2010	7.04		LUB 87	A		170	1				monitoring	16208
UMA219	10/21/2009	12.80			A		122	1				monitoring	16209
UMA222	10/21/2009	17.00			A		142	1				monitoring	16212
UMA224	1/13/2010	3.56		LUB 124	A		81	1				monitoring	16214
UMA225	1/13/2010	2.97		LUB 132	A		71.8	1				monitoring	16215
UMA228	1/13/2010	7.24		LUB 130	A		114.7	1				monitoring	16218
UMA231	9/15/2009	18.30		MORR 689	A		95	1				monitoring	16221
UMA232	9/15/2009	28.40		MORR 1549	A		86.66	1				monitoring	16222
UMA233	9/15/2009	54.50		MORR 1559	B	87.25		1				monitoring	16223
UMA234	11/2/2009	8.34		UMAT 1524	A		151.37	1				monitoring	16224
UMA235	11/2/2009	28.40		UMAT 1523	A		152	1				monitoring	16225
UMA236	11/2/2009	11.90		UMAT 5364	A		102.19	1				monitoring	16226
UMA237	11/2/2009	50.30		UMAT 1854	A		28.68	1				monitoring	16227
UMA238	11/2/2009	49.70		LUB 19	A		105.54	1				monitoring	16228
UMA239	11/3/2009	1.10		UMAT 5571	A		51.6	1				monitoring	16229
UMA240	11/3/2009	7.60		UMAT 5570	A		42.7	1				monitoring	16230

Table 7-1
Nitrate Concentrations from Third Synoptic Sampling Event
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Well ID	Date Sampled	Nitrate (mg/l)	GWMA Network Well	OWRD #	Aquifer	Basalt TD	Alluvial TD	Monitoring Well	Irrigation Well	Domestic Well	Industrial Well	Well Type	LASAR_ID
UMA241	11/3/2009	0.16		UMAT 5594	A		170.7	1				monitoring	16231
UMA242	11/3/2009	6.71		UMAT 5569	A		20.3	1				monitoring	16232
UMA243	11/2/2009	36.30		UMAT 5365	A		152.73	1				monitoring	16233
UMA244	11/4/2009	0.60		UMAT 5286	A		25	1				monitoring	16234
UMA245	11/10/2009	1.23		LUB 43	A		187	1				monitoring	16235
UMA246	11/10/2009	13.20		LUB 45	A		128	1				monitoring	16236
UMA247	1/12/2010	9.69		LUB 46	A		179	1				monitoring	16237
UMA248	1/7/2010	<0.005		LUB 50	A		19.84	1				monitoring	16238
UMA250	11/10/2009	14.90		LUB 44	A		85.02	1				monitoring	16240
UMA251	11/9/2009	27.80		LUB 55	A		87	1				monitoring	16241
UMA252	1/12/2010	41.70		LUB 47	A		109	1				monitoring	16242
UMA253	11/9/2009	26.00		LUB 73	A		75	1				monitoring	16243
UMA254	11/9/2009	4.02		LUB 77	A		30	1				monitoring	16244
UMA255	1/12/2010	4.92		LUB 63	A		36	1				monitoring	16245
UMA258	1/7/2010	0.09		LUB 53	A		19.8	1				monitoring	16248
UMA259	11/4/2009	0.86		UMAT 5290	A		65	1				monitoring	16249
UMA260	11/4/2009	9.04		UMAT 5287	A		18.5	1				monitoring	16250
UMA261	11/10/2009	8.82		LUB 42	A		133	1				monitoring	16251
UMA262	11/4/2009	4.38		UMAT 5292	A		65	1				monitoring	16252
UMA263	11/16/2009	7.60		UMAT 5525	A		68.95	1				monitoring	16253
UMA264	11/16/2009	8.15		UMAT 5526	A		90.7	1				monitoring	16254
UMA265	11/16/2009	6.59		UMAT 5528	A		109.9	1				monitoring	16255
UMA266	1/6/2010	46.30		LUB 9	A		37	1				monitoring	16256
UMA267	1/7/2010	48.70		LUB 11	A		24.8	1				monitoring	16257
UMA268	1/6/2010	38.20		LUB 1	A		17.6	1				monitoring	16258
UMA271	1/5/2010	57.50		LUB 32	B?	41.3		1				monitoring	16261
UMA272	1/6/2010	<0.005		MORR 574	B	350					1	industrial	16262
UMA273	1/5/2010	53.00		LUB 29	B?	54.9		1				monitoring	16263
UMA274	1/6/2010	26.30		LUB 27	A		19.4	1				monitoring	16264

Table 8-1
Individual Well Nitrate Trends - Depot Landfill Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Well ID	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Minimum	Maximum	Mean	Median	n	% BDL	Slope (ppm/yr)	Confidence Level		
11-5	Oct-90	Nov-10	1.8	13	10.75	11	32	0%	-0.12	99%	Decreasing	Increase then Decrease
MW-33	Jun-88	Nov-10	1.8	17	14.47	15.0	33	0%	-0.13	99%	Decreasing	Increase then Decrease
MW-34	Jun-88	Nov-10	3.5	16	13.09	13.1	33	0%	0	12%	NS80	Increase then Decrease
MW-35	Jun-88	Nov-10	2.5	17	11.87	11.0	33	0%	-0.23	99%	Decreasing	Large decrease then slight increase
MW-36	Jun-88	Nov-10	2.0	16	13.32	14.00	33	0%	-0.06	89%	Decreasing	Increase then Decrease

# of Increasing Trends ==>	0
# of Decreasing Trends ==>	4 (80%)
# of Flat Trends ==>	0
# of Insignificant Trends ==>	1 (20%)
Avg slope of significant trends at the wells ==>	-0.13
Avg slope of all trends at the wells ==>	-0.11

Notes:

n = number of samples

BDL = below detection limit

NS80 = not significant at an 80% confidence level

E:\LUB\Depot\Data from COE\Landfill\[Depot Landfill Nitrate Concentrations.xlsx]Summary Table

Table 8-2
Recent Changes in Individual Well Nitrate Trends - Depot Landfill Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Well ID	Starting Date	Ending Date	1988 through 2005 Trend Analysis Results			1988 through 2010 Trend Analysis Results			Difference in Slope	Change from 2005 to 2010
			Slope (ppm/yr)	Confidence Level	Trend Direction	Slope (ppm/yr)	Confidence Level	Trend Direction		
11-5	Oct-90	Nov-10	0.0	53%	NS80	-0.12	99%	Decreasing	-0.12	Improved
MW-33	Jun-88	Nov-10	-0.01	85%	Decreasing	-0.13	99%	Decreasing	-0.12	Improved
MW-34	Jun-88	Nov-10	0.04	82%	Increasing	0.0	12%	NS80	-0.04	Improved
MW-35	Jun-88	Nov-10	-0.49	99%	Decreasing	-0.23	99%	Decreasing	0.26	Worsened
MW-36	Jun-88	Nov-10	0.01	43%	NS80	-0.06	89%	Decreasing	-0.07	Improved

Summary of Changes				
# Wells	Change	Average Change	Median Change	Maximum Change
1 well	Worsened	0.26 ppm/yr	0.26 ppm/yr	0.26 ppm/yr
4 well	Improved	0.08 ppm/yr	0.09 ppm/yr	0.12 ppm/yr

= confidence level changed enough to change statistical significance (3 wells)

= slope changed direction (1 well)

E:\LUB\2011 Analysis of GW NO3 Conc in LUB GWMA\[Depot Landfill Nitrate Concentrations.xlsx]Table 8-2

Table 10-1
Summary of Nitrate Concentrations
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Source of Information	Number of Wells	Timeframe of Data Set		Minimum	Average	Median	Maximum	Wells with Average Nitrate Value Greater than 7 mg/l		Wells with Average Nitrate Value Greater than 10 mg/l	
		Start	End					#	%	#	%
LUB GMWA Well Network (1)	38	Jul-90	Nov-09	<0.005	9.9	5.6	160	17	45%	14	37%
Food Processing Site Monitoring Wells (2)	142	Jun-87	Nov-09	<0.02	17.6	11.6	129	100	70%	67	47%
Three Mile Canyon Farms Monitoring Wells	15	Jun-00	Sep-09	0.59	29.6	27.4	100.5	14	93%	13	87%
Public Supply Wells	3	Jun-84	Jan-11	0.17	6.5	6	12.9	1	33%	1	33%
Third Synoptic Sampling Event (3)	107	Sep-09	Jan-10	<0.005	15.3	8.82	103.4	62	58%	48	45%
Depot Landfill Wells	5	Jun-88	Nov-10	1.8	12.7	13	17	5	100%	5	100%
Real Estate Transaction Database (3) (4) (5)	372	Dec-89	Aug-09	<0.1	3.92	2.06	56	73	20%	42	11%
Summary including RET Database (6)	682							272	40%	190	28%
Summary excluding RET Database	310							199	64%	148	48%

Notes: (1) = The maximum value of 160 mg/l does not fit with the rest of the data from this well and is suspect. The next highest value from the network is 64 mg/l.
The LUB GWMA Well Network was sampled as part of the Third Synoptic Sampling Event.
It is possible some of the RET database wells were also sampled as part of the synoptic sampling event.
(2) = This table includes data from all 142 wells at all food processing sites. The timeframes of each well's data set is different.
One well (UMA198) is sampled as part of the LUB GWMA well network and the food processing site monitoring well network. It is included in the LUB GWMA well network in this table.
(3) = This data set largely consists of one value per well so there is no average value.
(4) = The average value listed is likely lower than the true average because a concentration of zero was substituted for values listed as below detection limits.
(5) = Due to the uncertainty of the identify of wells in the Real Estate Transaction database, it is not possible to directly determine if these wells tap the alluvial aquifer or the basalt aquifer.
(6) = Because the LUB GWMA well network was sampled as part of the Third Synoptic Sampling Event, and one well (UMA198) is known to be part of the LUB GWMA well network and the food processing site monitoring well network, the actual number of wells represented in Table 10-1 is likely around 650.

E:\LUB\2011 Analysis of GW NO3 Conc in LUB GWMA\[Summary of All Trends Wells.xlsx]Concentration Summary

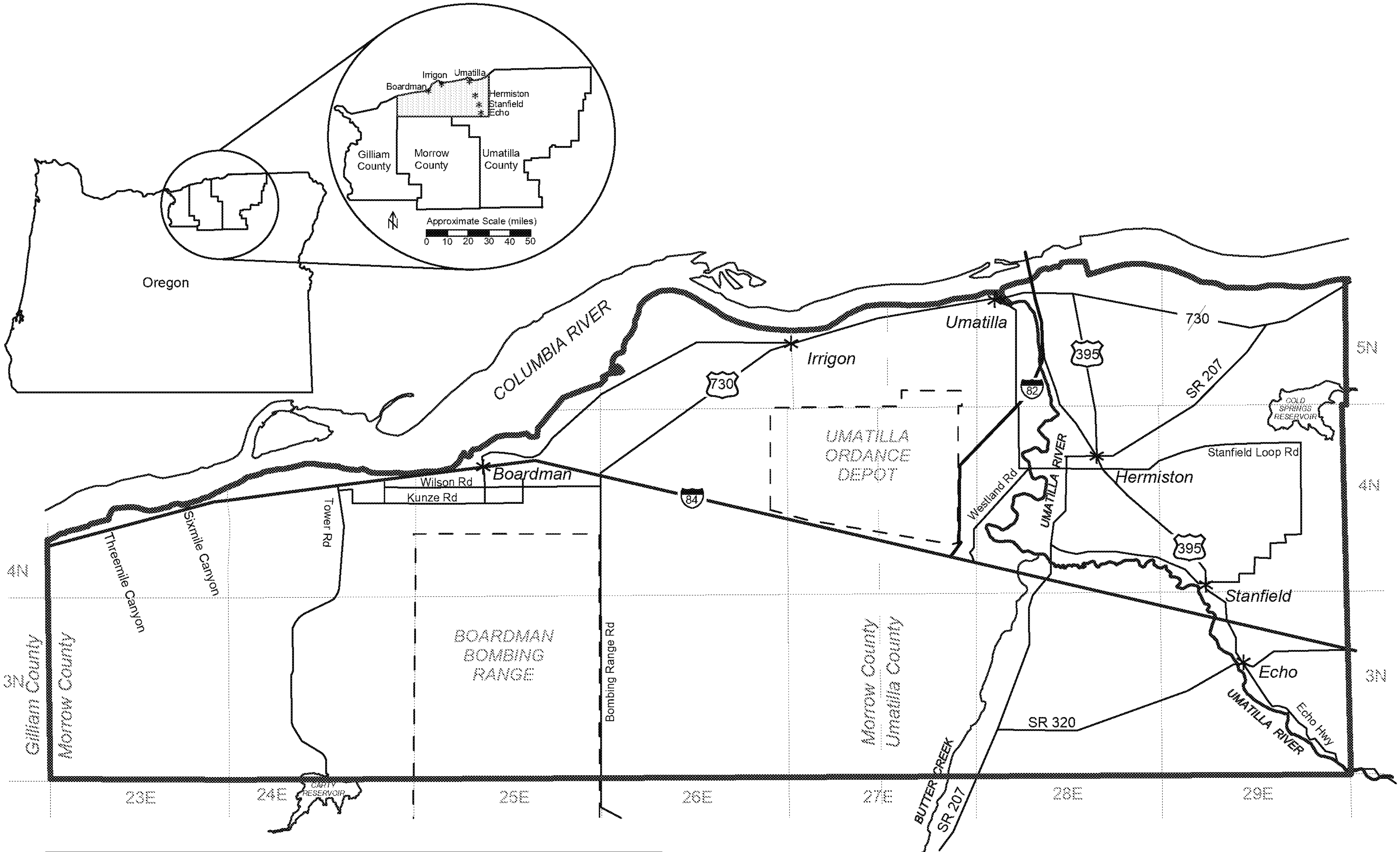
Table 10-2
Summary of Nitrate Trends
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Type of Well	Timeframe of Data Set		Increasing		Decreasing		Flat		Statistically Insignificant		TOTAL
	Start	End	#	%	#	%	#	%	#	%	
LUB GWMA Well Network	Jul-90	Nov-09	21	55%	8	21%	1	3%	8	21%	38
Food Processing Site Monitoring Well (1)	Jun-87	Nov-09	74	53%	33	24%	1	1%	32	23%	140
Three Mile Canyon Farms Monitoring Well	Jun-00	Sep-09	5	33%	4	27%	0	0%	6	40%	15
Public Supply Well	Jun-84	Jan-11	2	67%	0	0%	0	0%	1	33%	3
Depot Landfill Well	Jun-88	Nov-10	0	0%	4	80%	0	0%	1	20%	5
TOTAL			**102**	**51%**	**49**	**24%**	**2**	**1%**	**48**	**24%**	**201**

Notes: (1) One well is sampled as part of both the LUB GWMA well network and the food processing site well networks.
It is counted only in the LUB GWMA well network in this table.
(2) While not a calculated trend, a comparison of the first and third synoptic sampling events showed 54% increased, 24% decreased, and 22% did not change.

E:\LUB\2011 Analysis of GW NO3 Conc in LUB GWMA\[Summary of All Trends Wells.xlsx]Trend Summary

Figure 1-1
Location and Boundaries of Lower Umatilla Basin Groundwater Management Area
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



Lower Umatilla Basin Groundwater Management Area Boundaries

North: Columbia River
South: 2N/3N Township Boundary
East: 29E/30E Range Boundary
West: 22E/23E Range Boundary (also the Morrow / Gilliam County line)

Figure 3-1
LOWESS Lines and Trend Lines Through LUB GWMA Well Network Nitrate Data
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

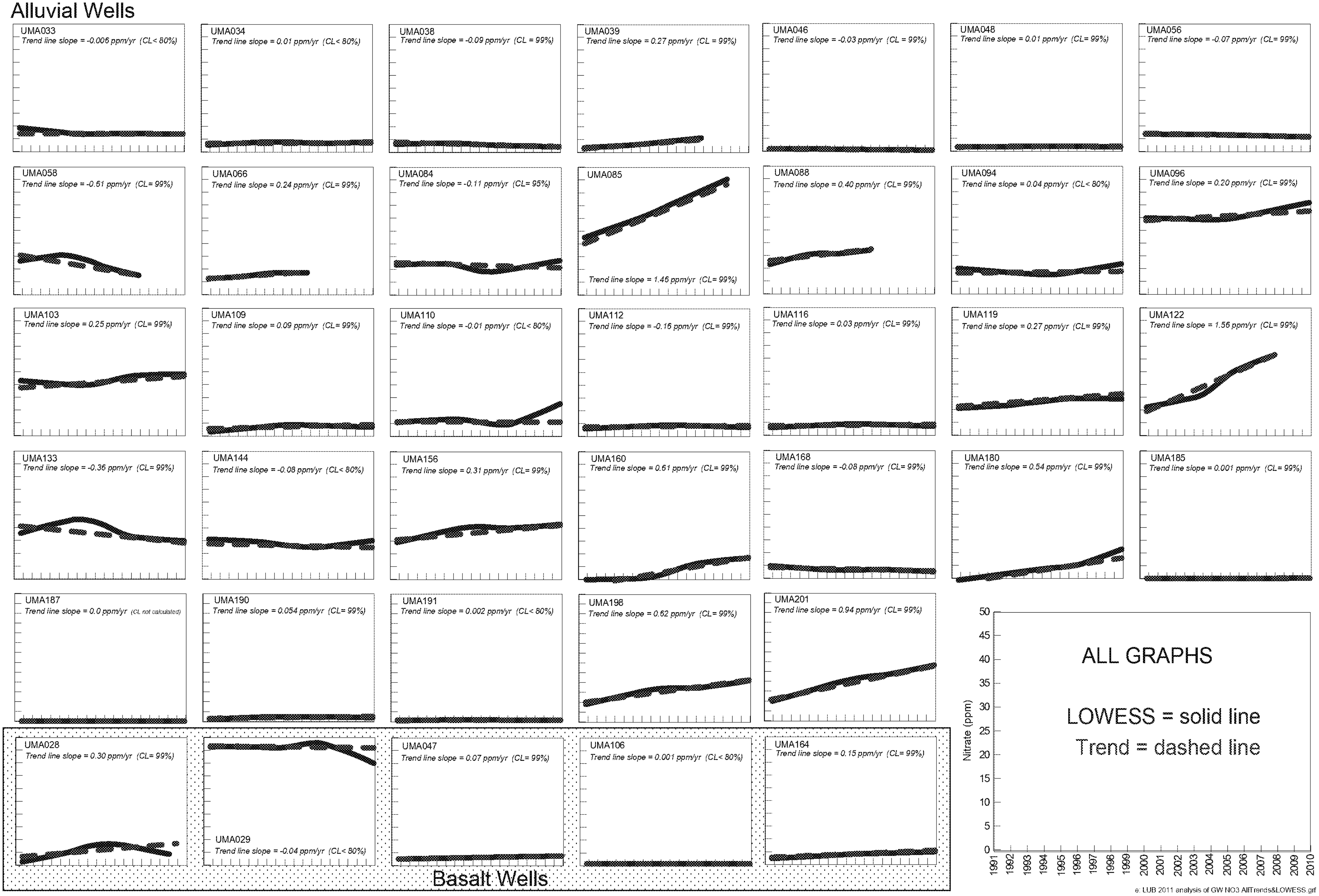
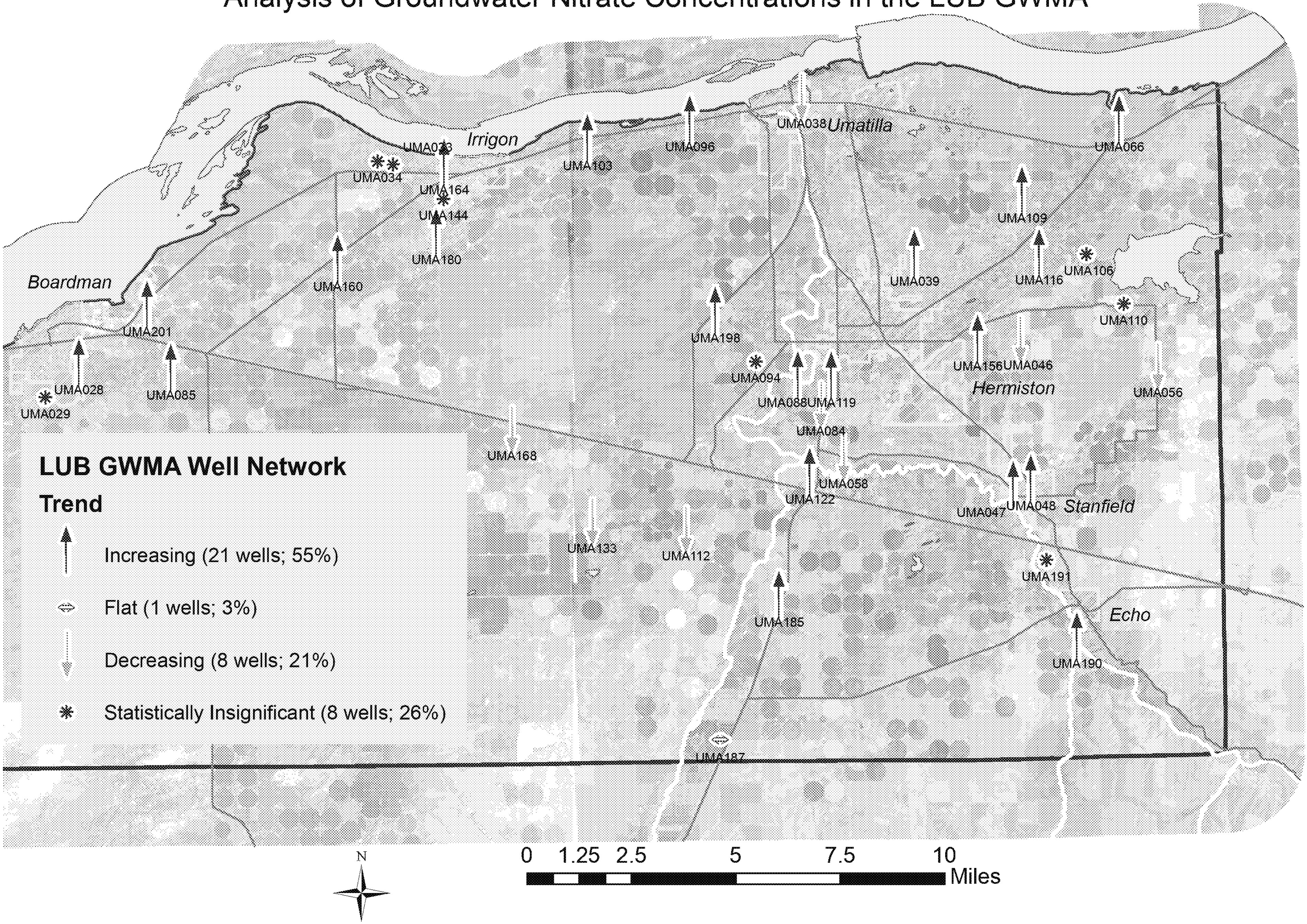


Figure 3-2
Nitrate Trends at LUB GWMA Well Network
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



ED_005296_00001040-00056

Figure 3-3
LUB GWMA Area-Wide Trend
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

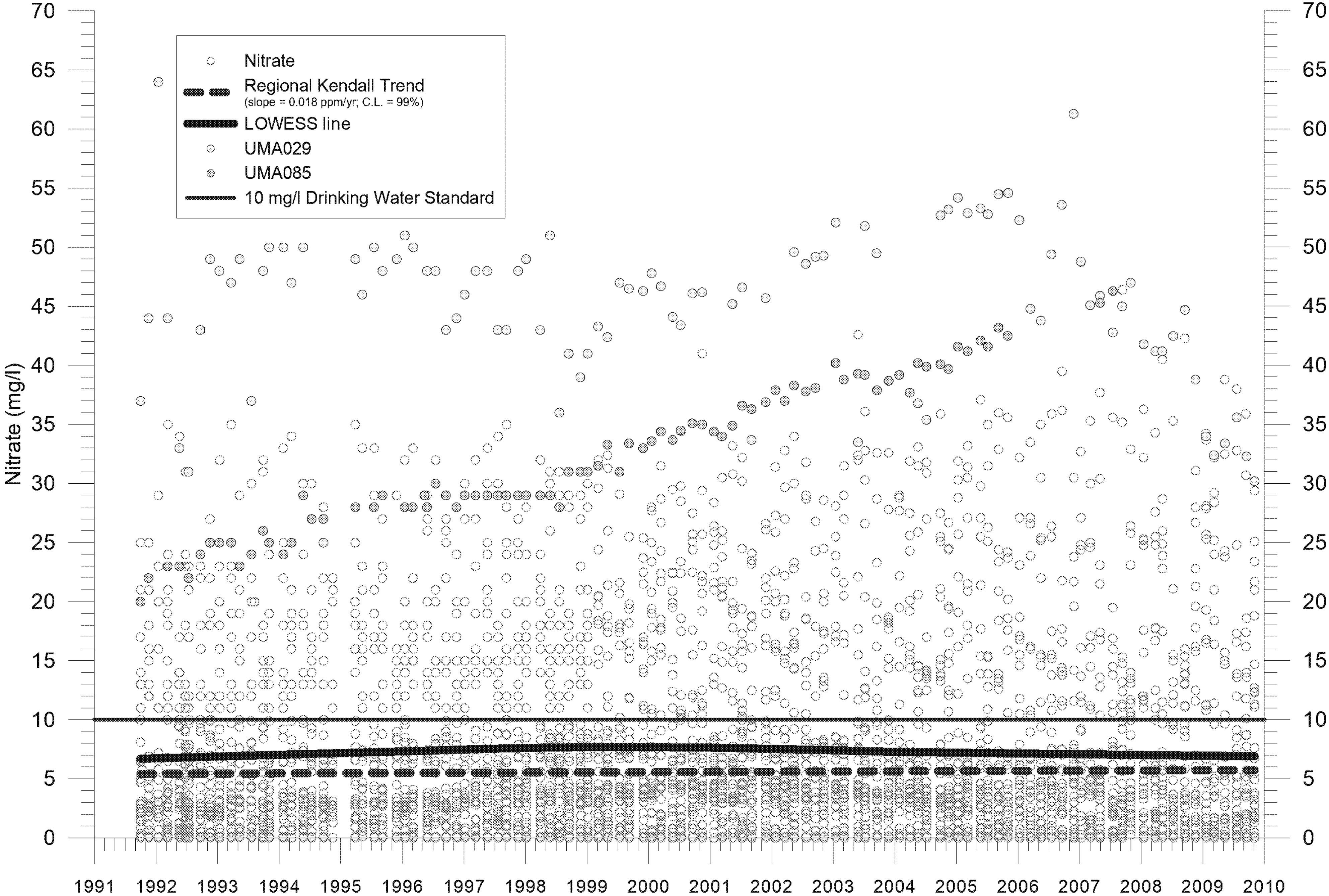
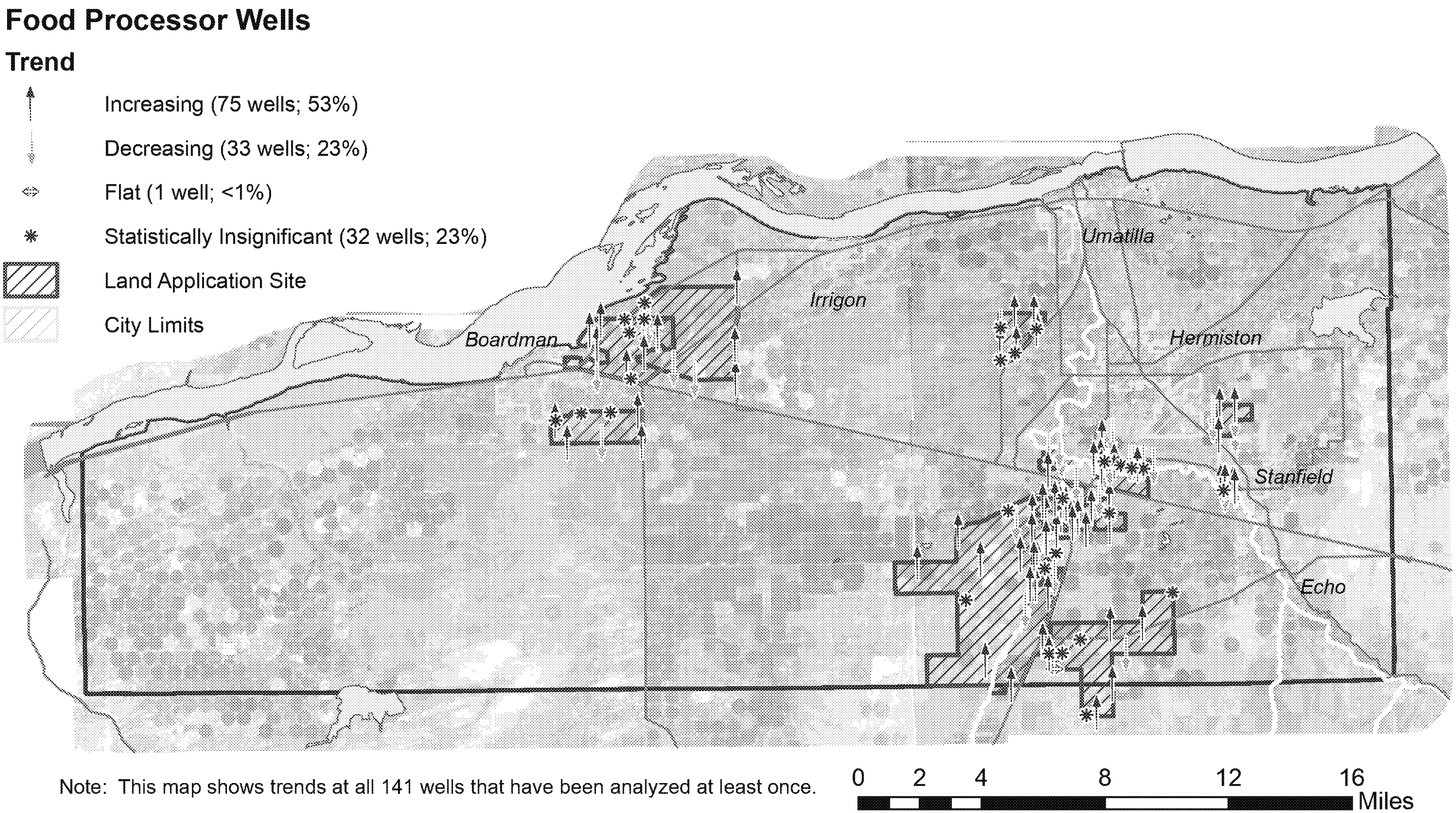


Figure 4-1
Nitrate Trends at Food Processor Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



Note: This map shows trends at all 141 wells that have been analyzed at least once.

Figure 4-2
Summary of All Trends at Food Processor Wells
Analysis of Groundwater Nitrate Concentrations in the LUBGWMA

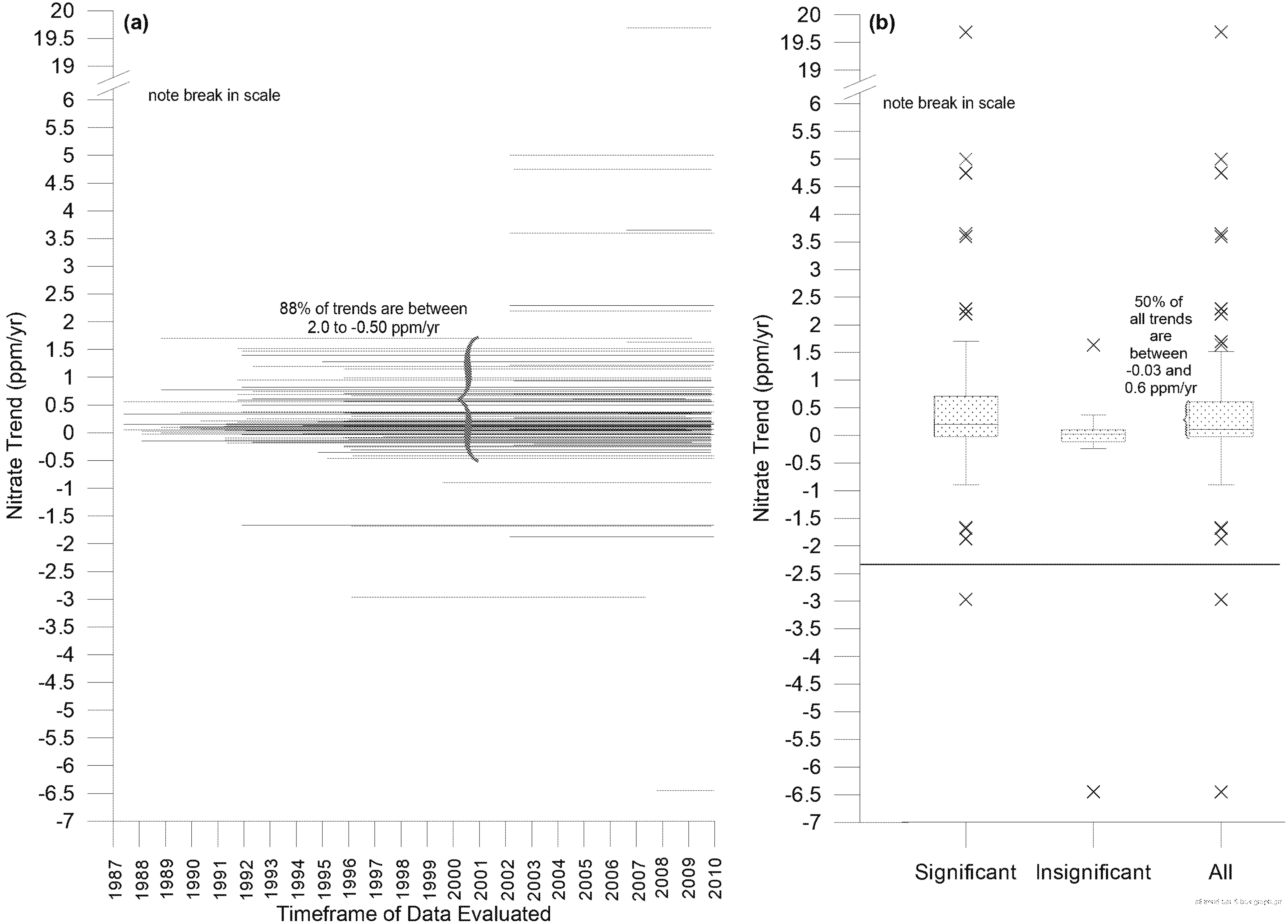


Figure 4-3
Trends at Food Processor Wells Analyzed Three Times
Analysis of Groundwater Nitrate Concentraitons in the LUBGWMA

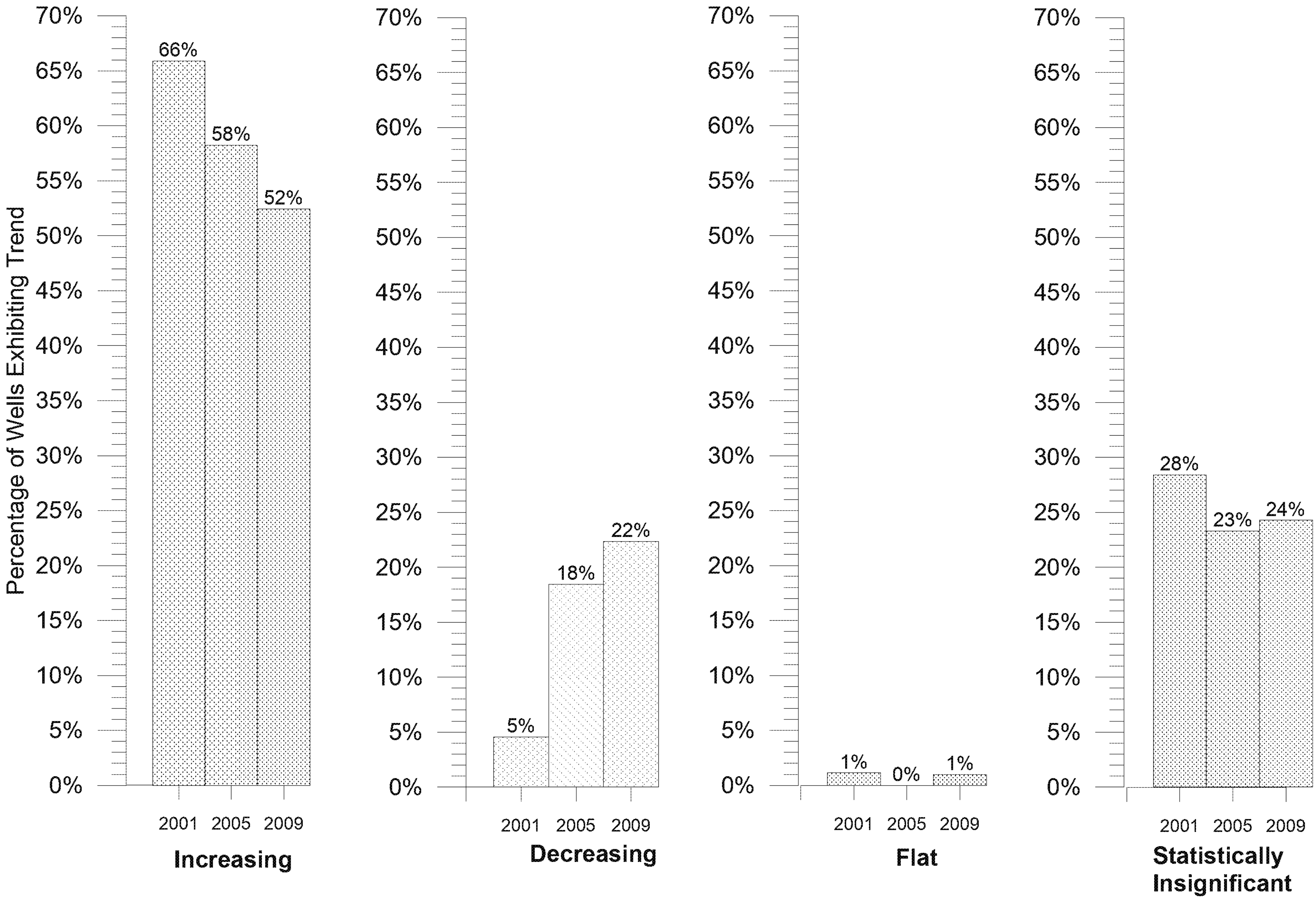
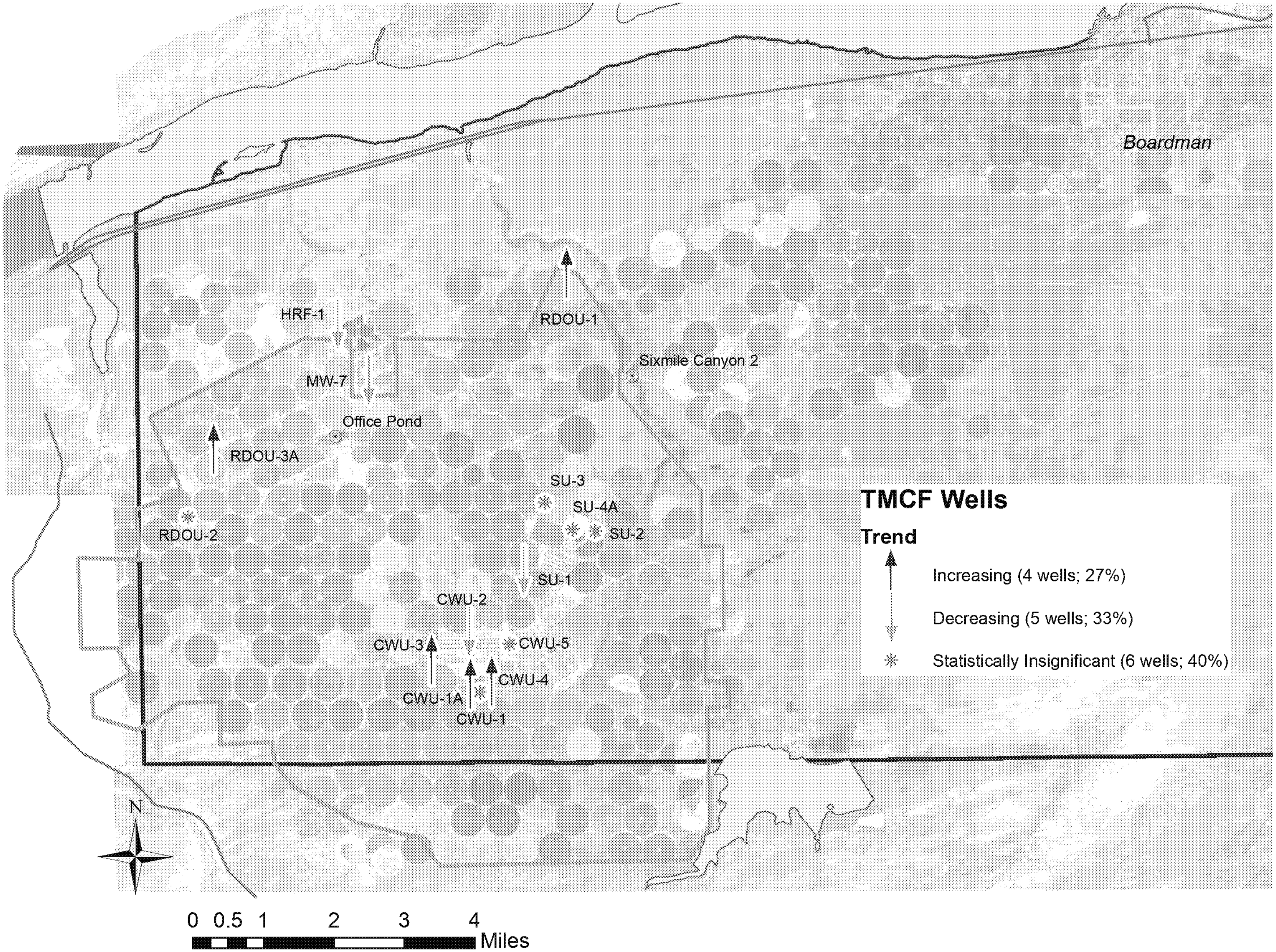
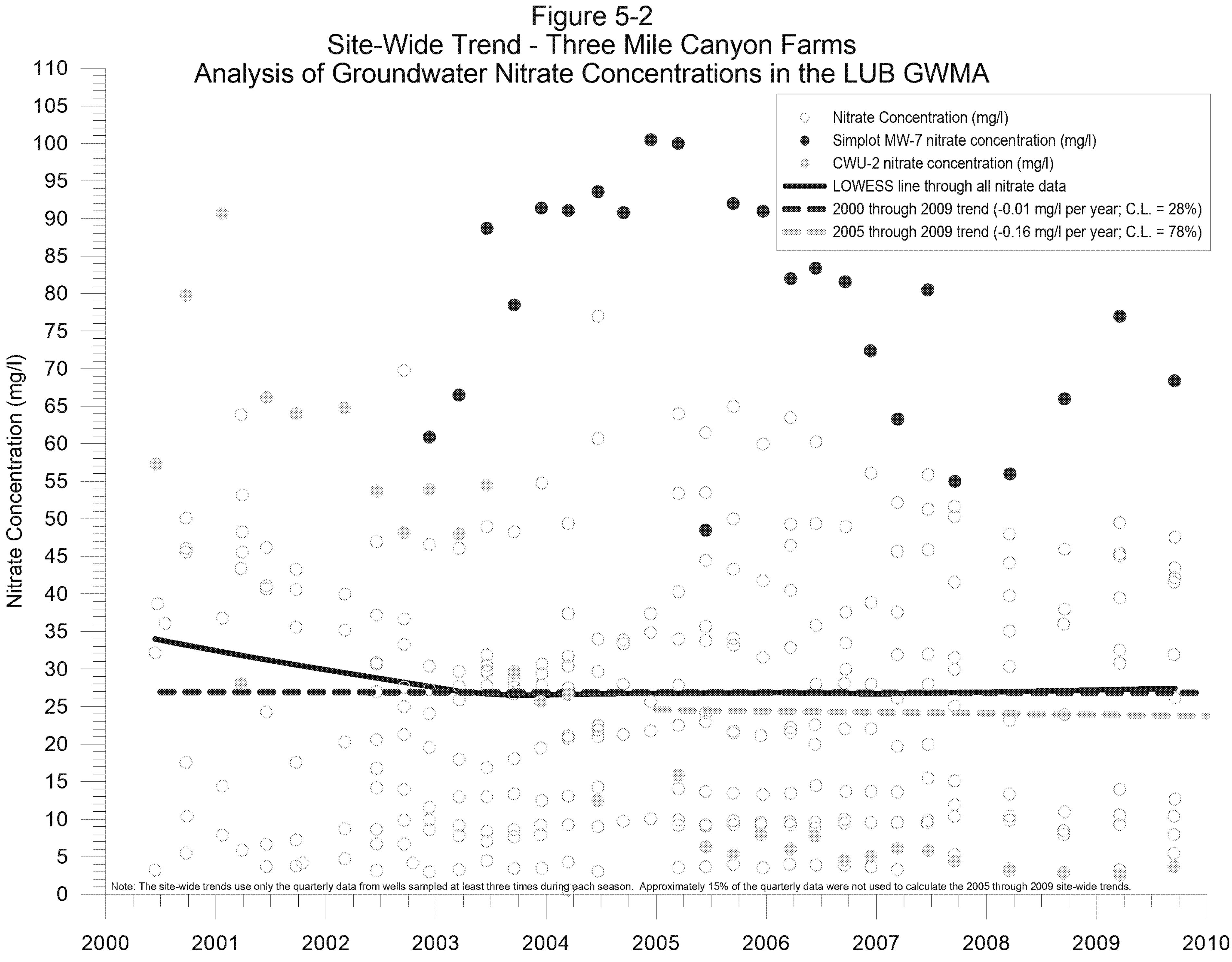


Figure 5-1
Nitrate Trends at Three Mile Canyon Farms Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA





e: lub threemilecanyonfarms alldata&trends.grf

Figure 6-1
Nitrate Trends at Three Public Water Supply Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

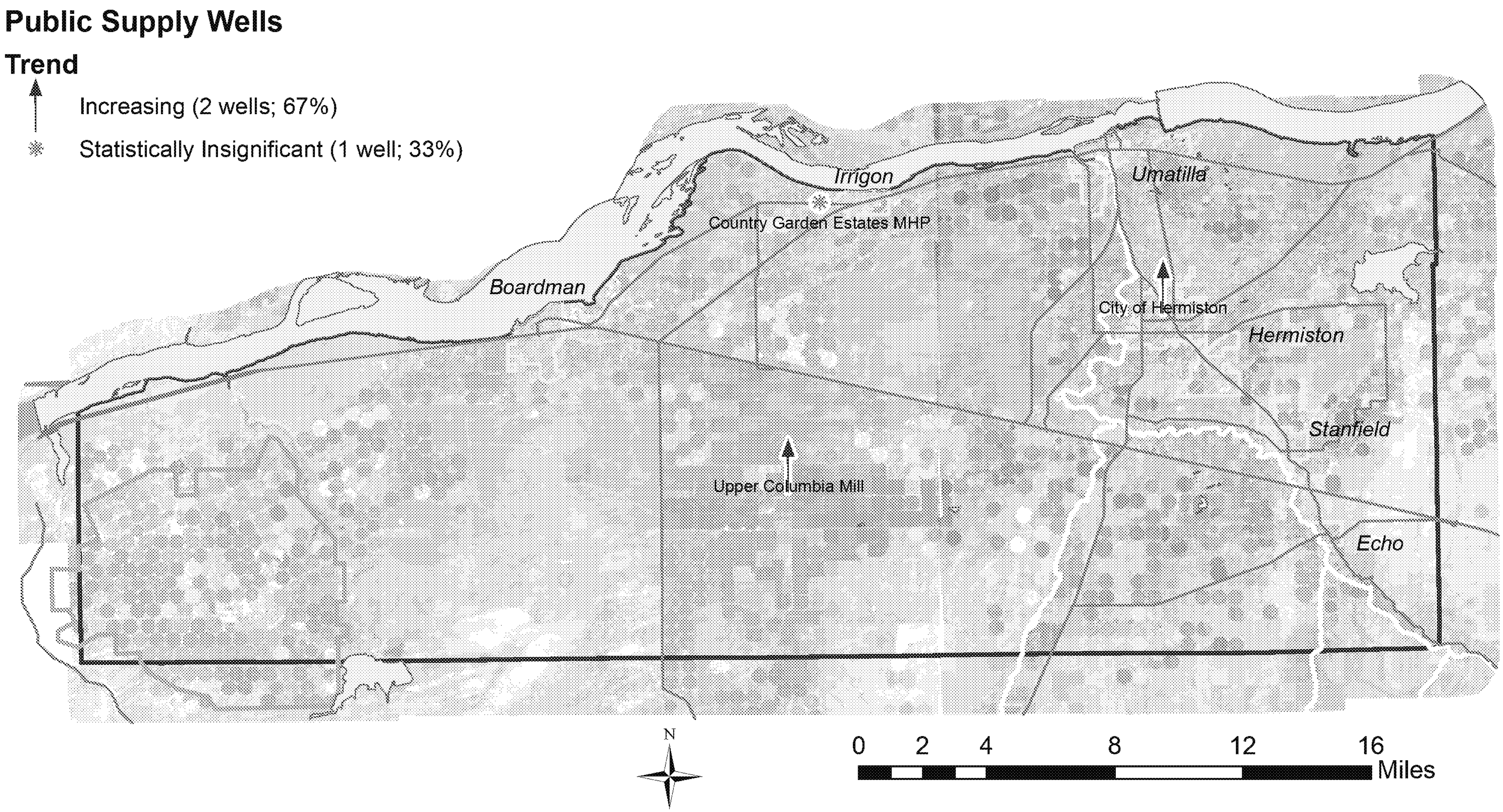
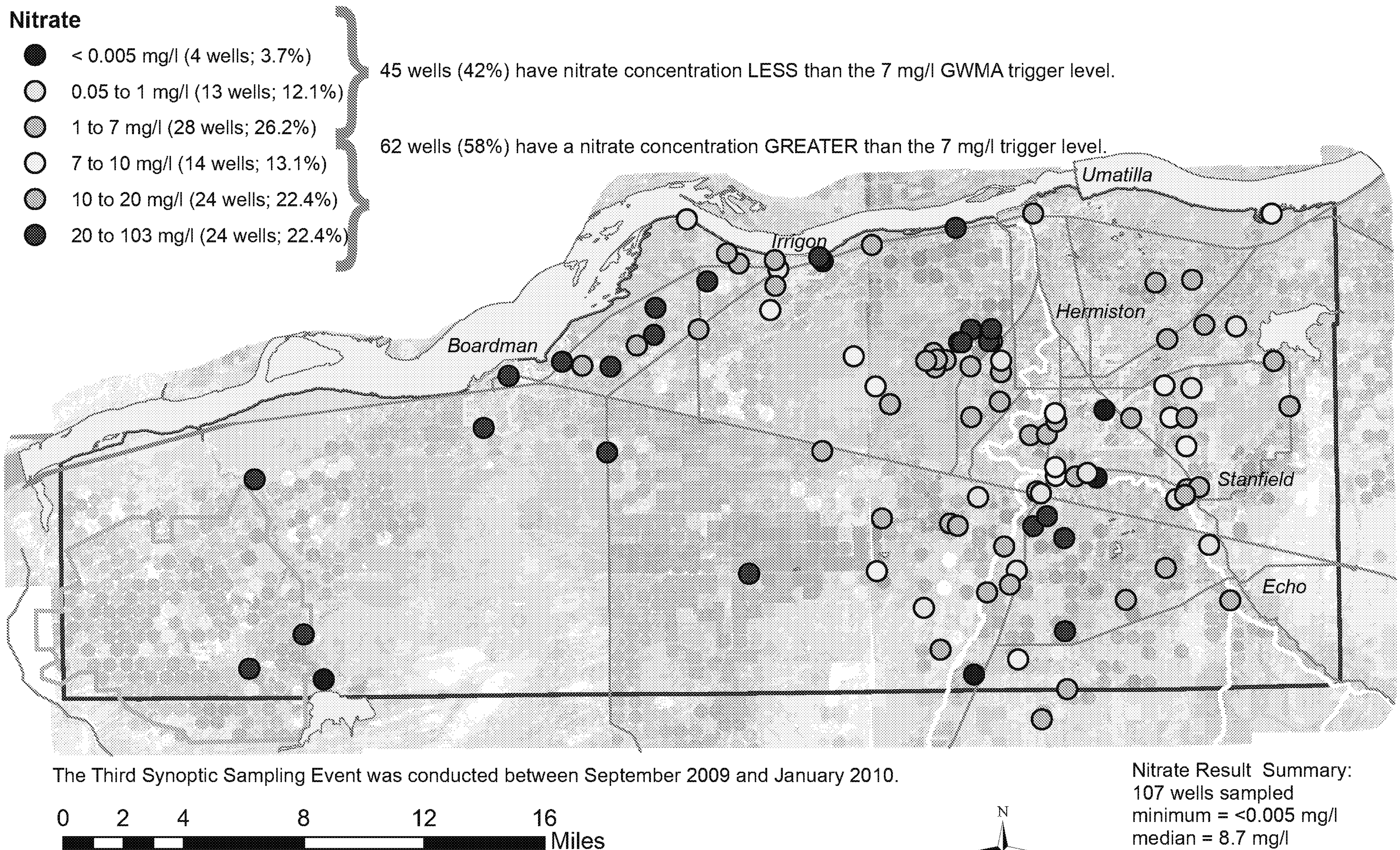


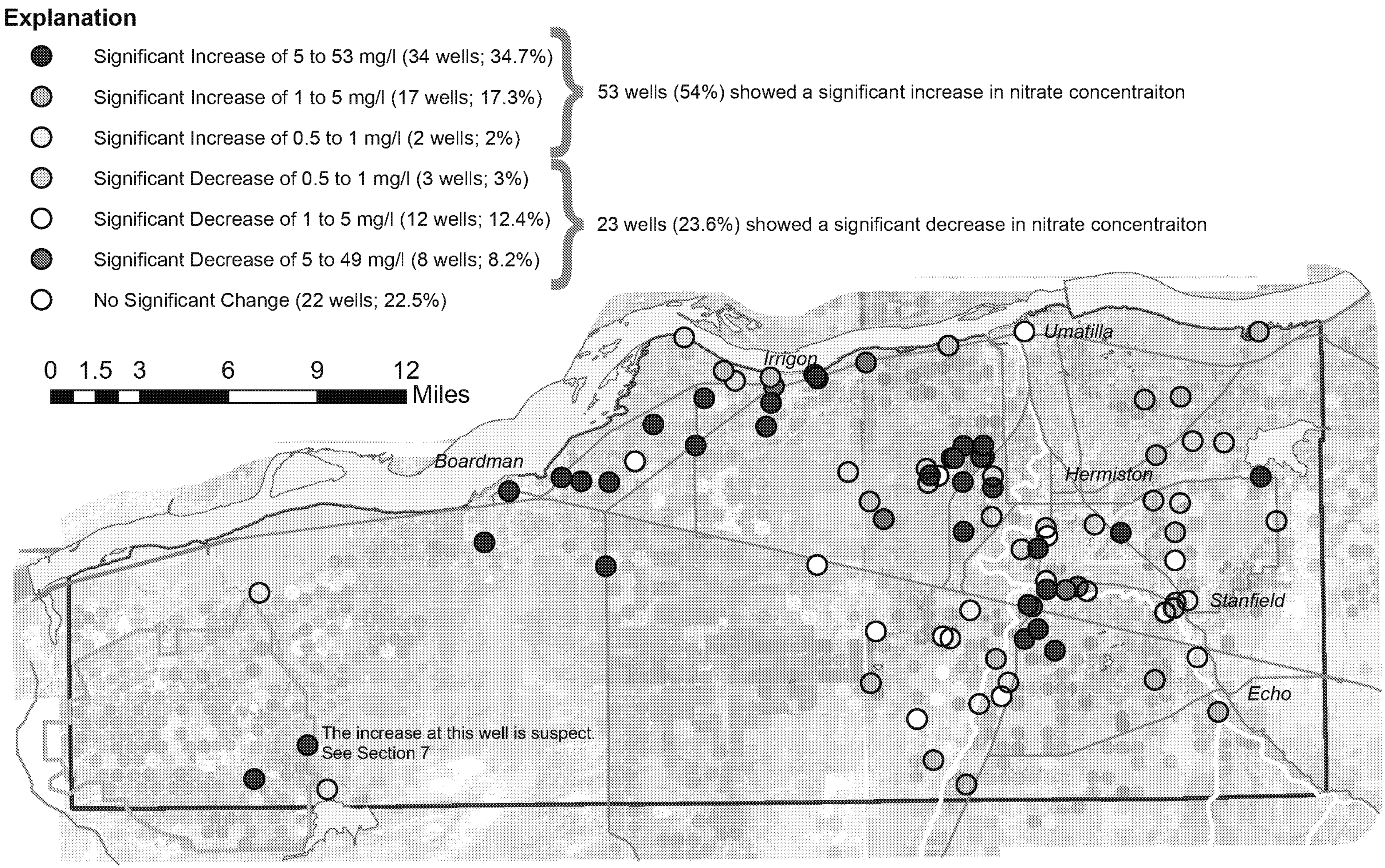
Figure 7-1
Nitrate Concentrations from Third Synoptic Sampling Event
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



The Third Synoptic Sampling Event was conducted between September 2009 and January 2010.

Nitrate Result Summary:
107 wells sampled
minimum = <0.005 mg/l
median = 8.7 mg/l
average = 14.7 mg/l
maximum = 103.4 mg/l
IQR = 3.0 to 18.3 mg/l

Figure 7-2
Significant Changes in Nitrate Concentrations Between the First and Third Synoptic Sampling Events
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

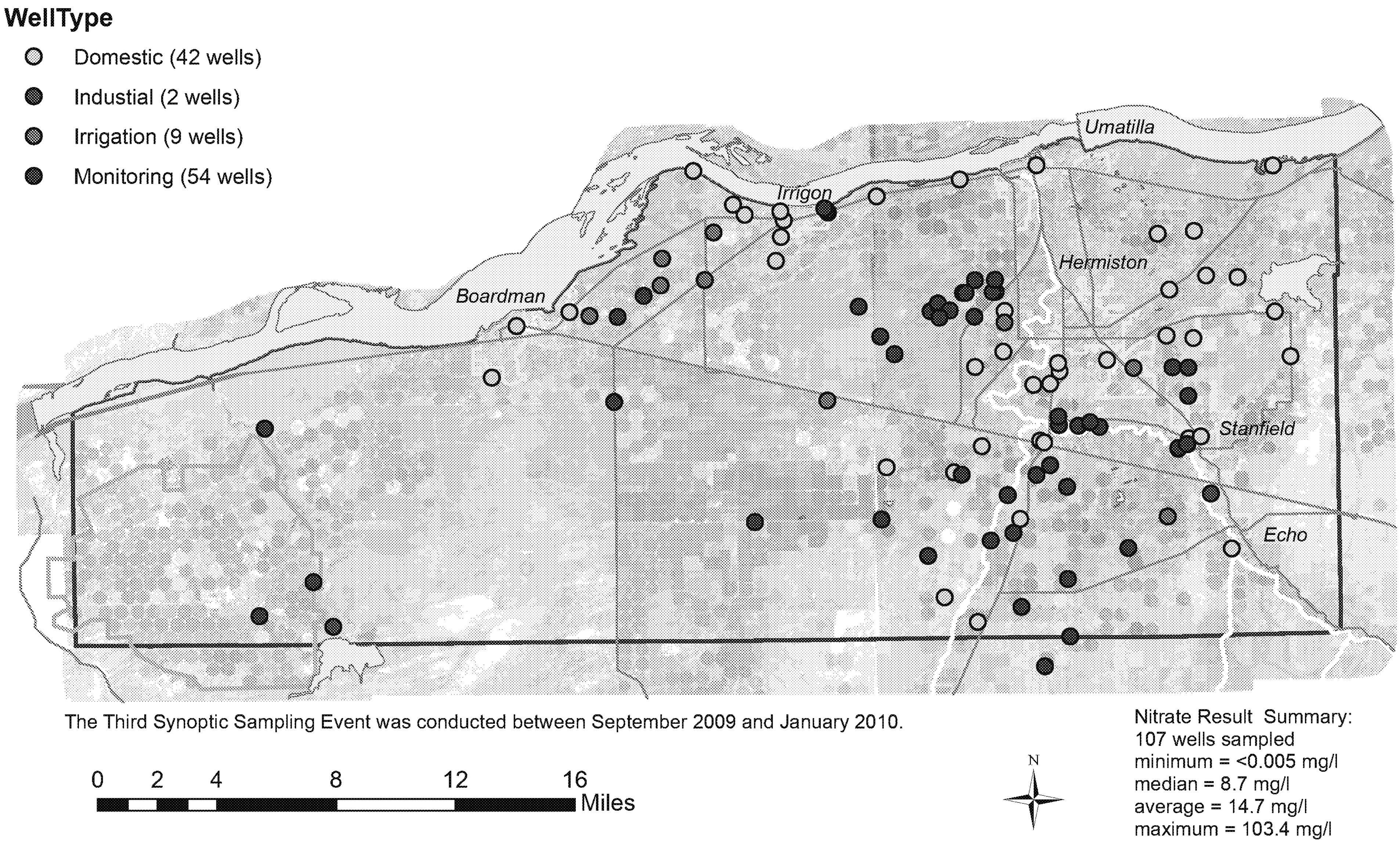


The First Synoptic Sampling Event was conducted in June and July 1992. The Third Synoptic Sampling Event was conducted between September 2009 and January 2010.

98 of the 107 wells sampled in Third Synoptic Event were also sampled in the First Synoptic Event.

A "significant difference" is defined here as having a relative percent difference of >10% and an actual difference of more than 0.5 mg/l.

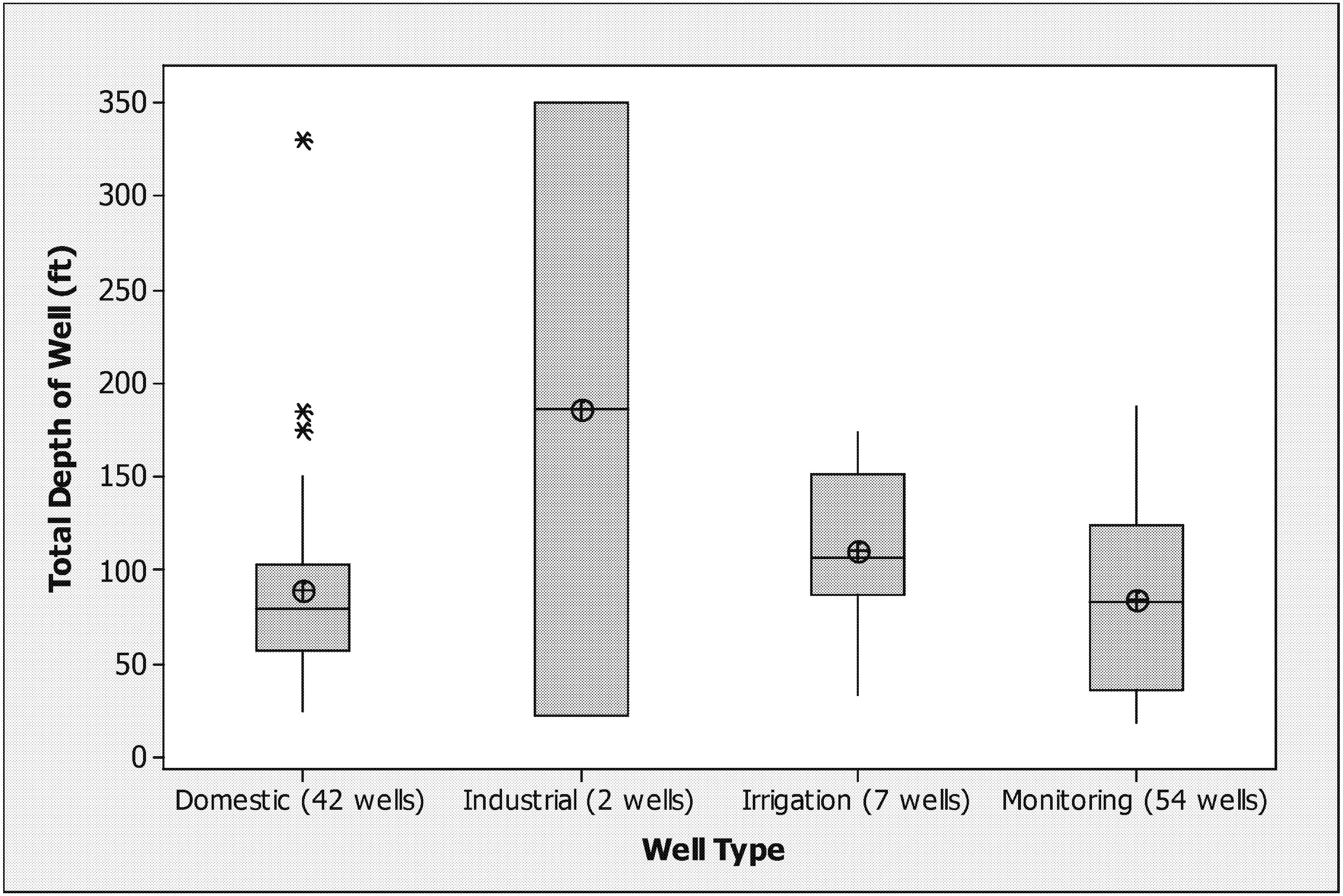
Figure 7-3
Types of Wells Sampled In Third Synoptic Sampling Event
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



The Third Synoptic Sampling Event was conducted between September 2009 and January 2010.

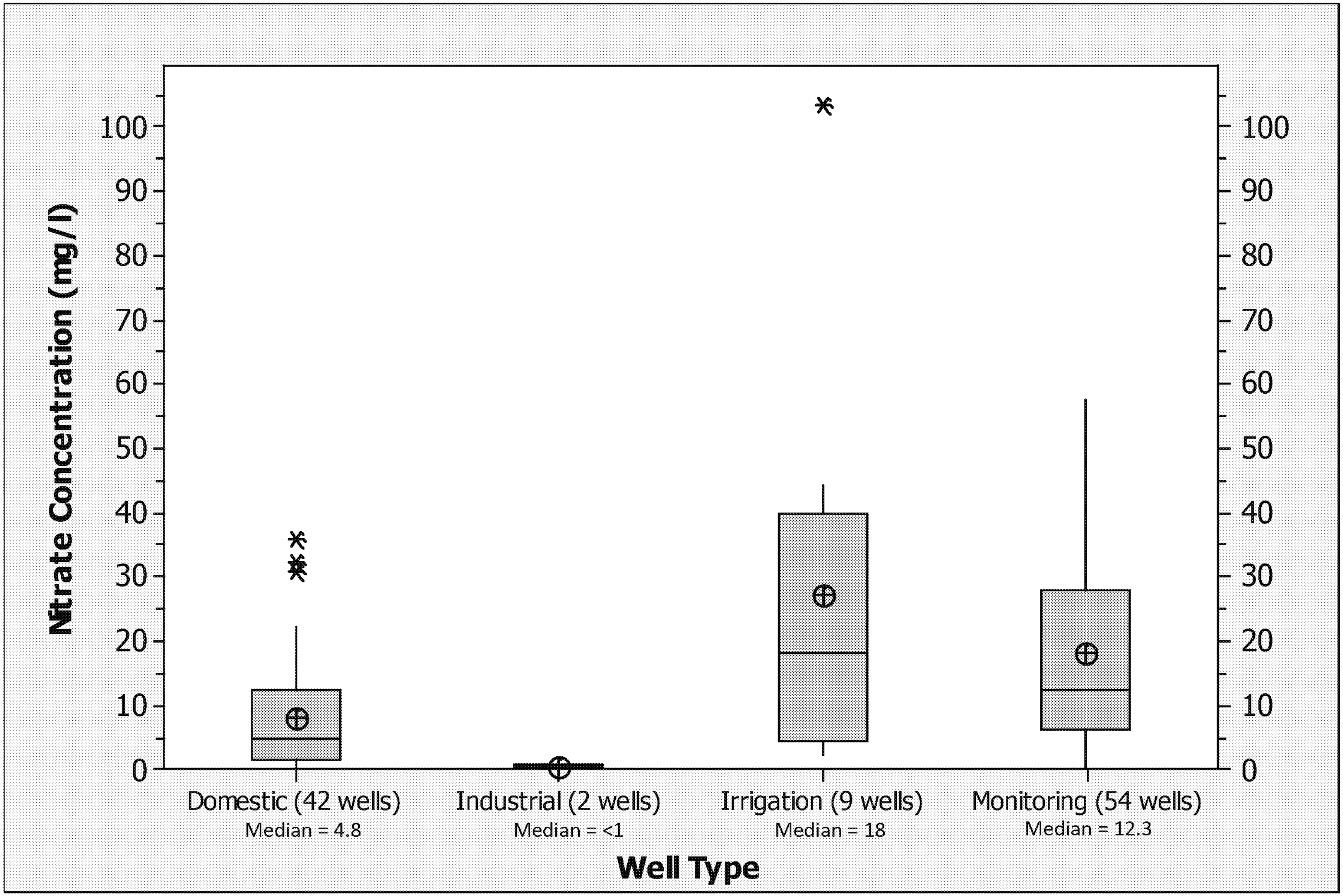
Nitrate Result Summary:
107 wells sampled
minimum = <0.005 mg/l
median = 8.7 mg/l
average = 14.7 mg/l
maximum = 103.4 mg/l
IQR = 3.0 to 18.3 mg/l

Figure 7-4
Total Well Depth by Well Type
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



Note: The Kruskal-Wallis test of medians does not indicate a statistically significant difference between the depths of domestic wells and monitoring wells.

Figure 7-5
Nitrate Concentrations by Well Type
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA



Note: The Kruskal-Wallis test of medians indicates a statistically significant difference between nitrate concentrations at domestic wells and monitoring wells.

Figure 8-1
Nitrate Trends at Depot Landfill Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

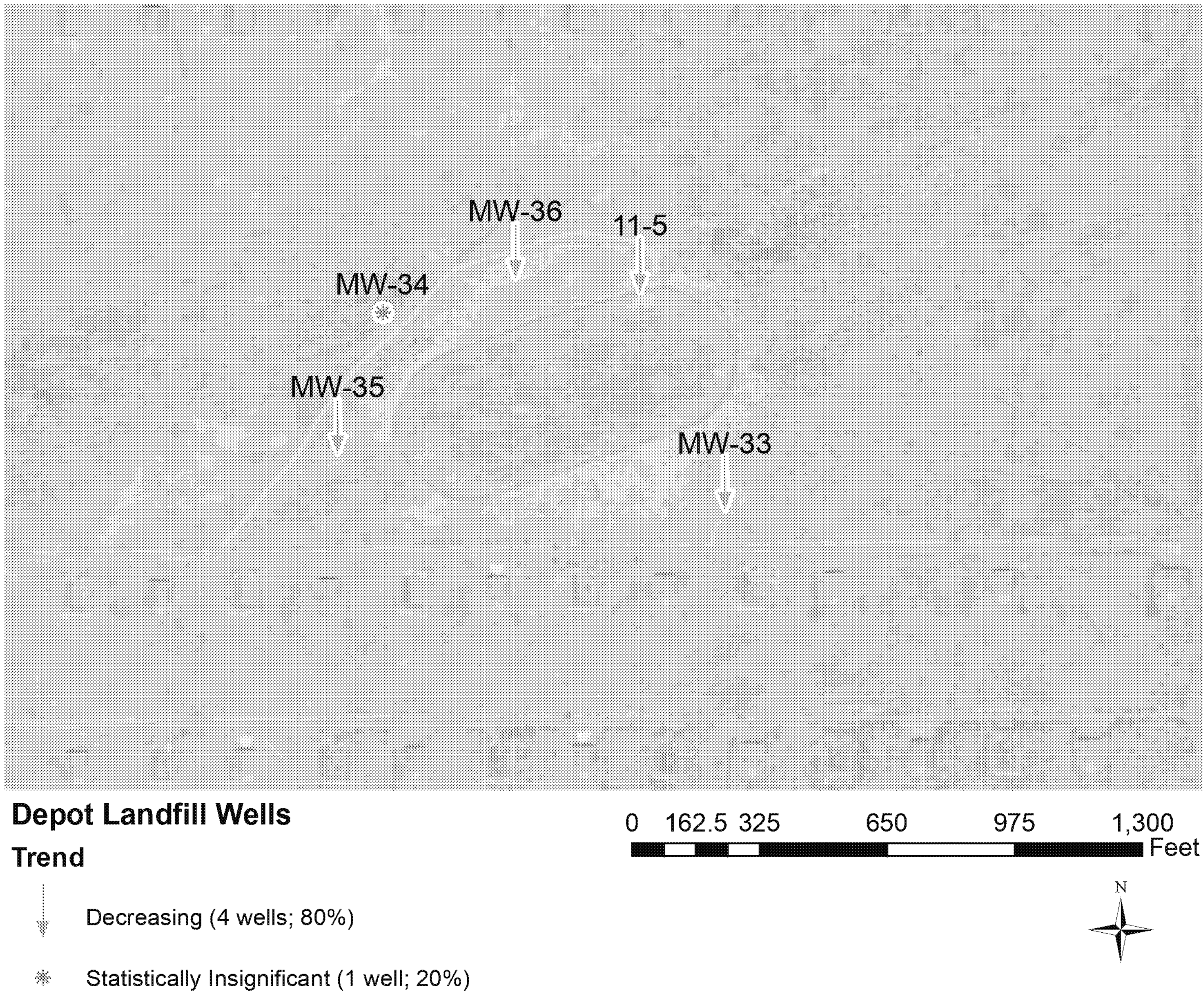


Figure 8-2
Site-Wide Nitrate Trend at Depot Landfill
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

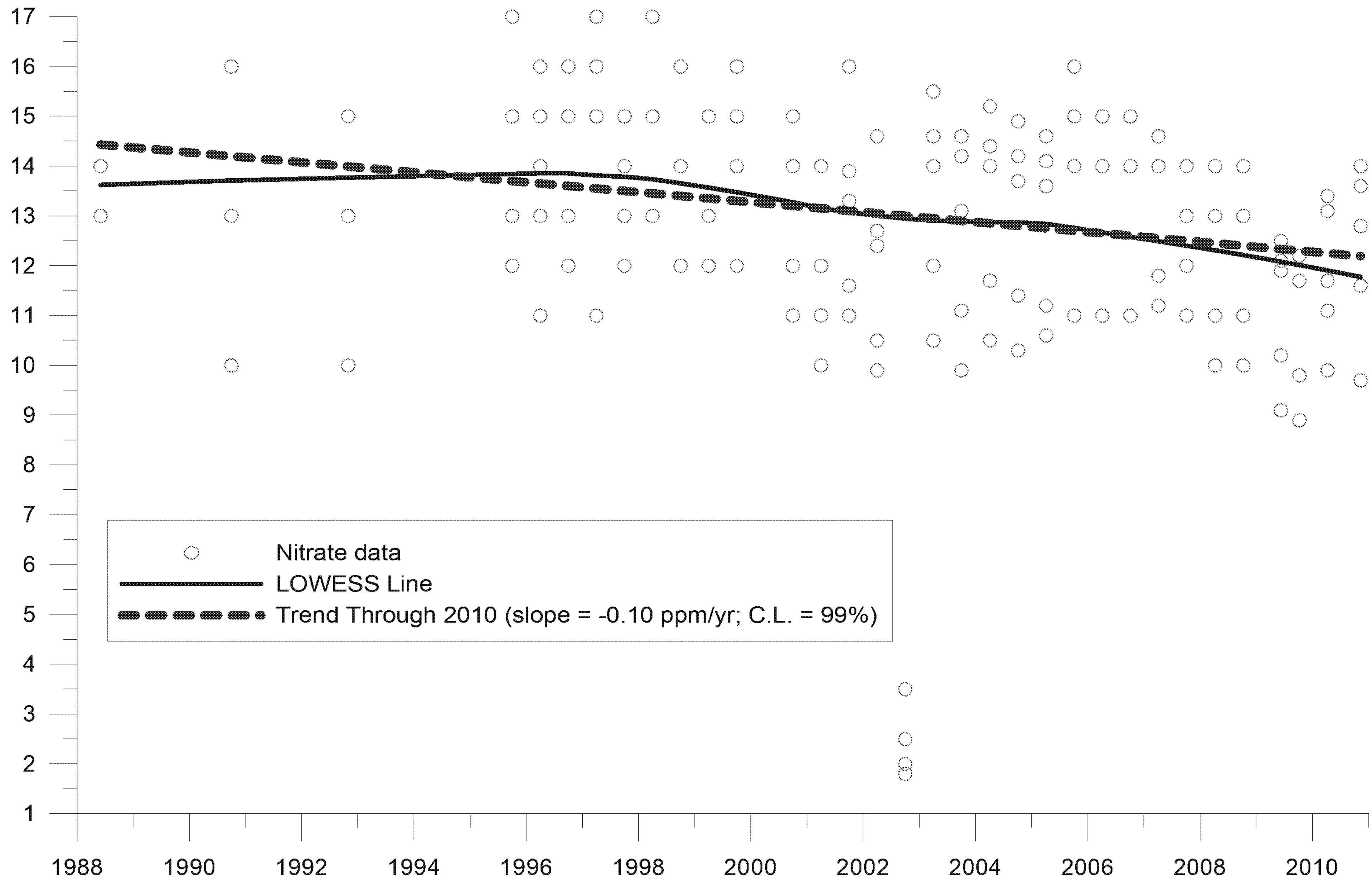


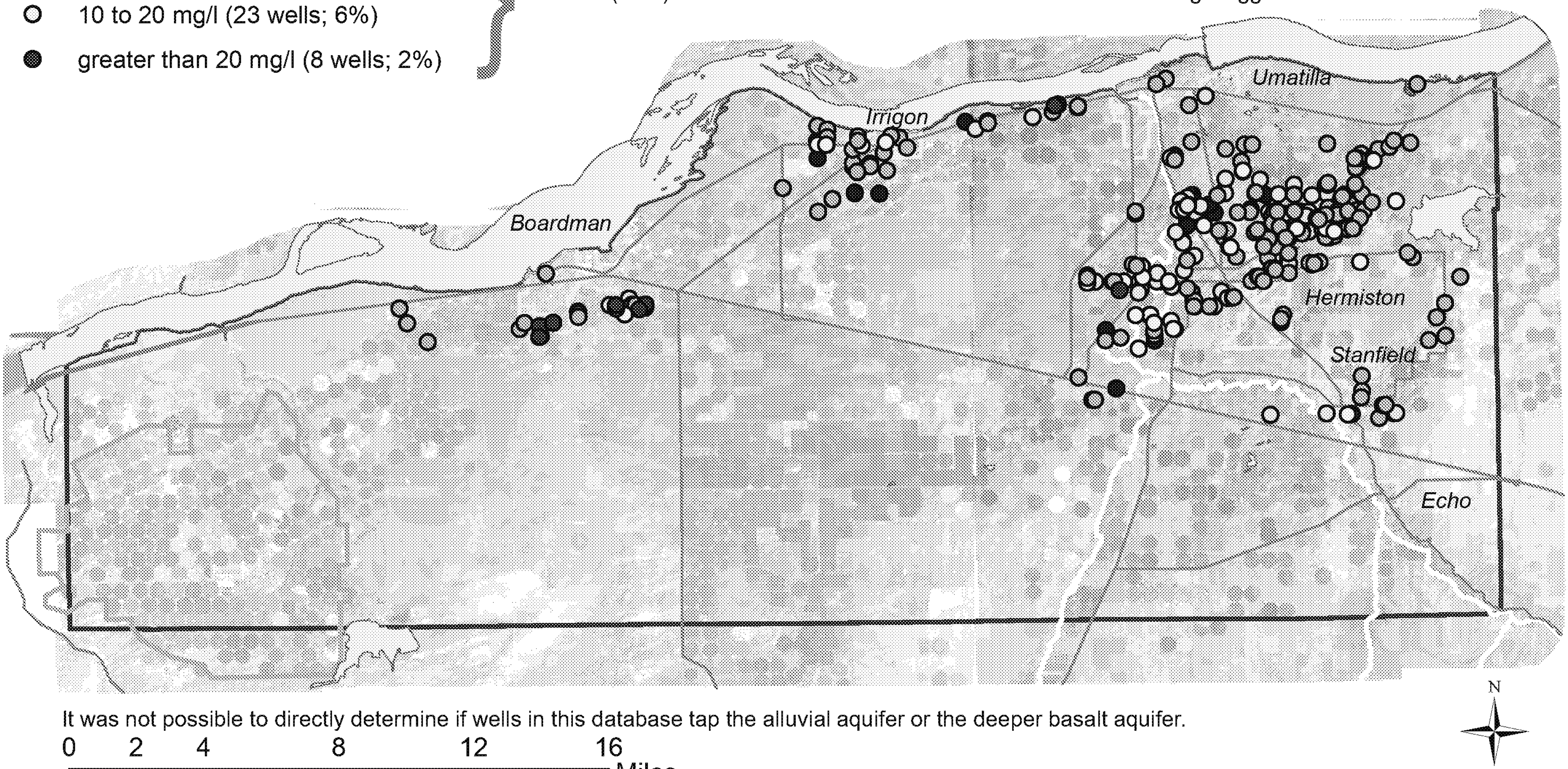
Figure 9-1
Nitrate Concentrations from Real Estate Transaction Database
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

Nitrate Concentration

- not detected (43 wells; 12%)
- detected up to 1 mg/l (95 wells; 26%)
- 1 to 7 mg/l (169 wells; 45%)
- 7 to 10 mg/l (34 wells; 9%)
- 10 to 20 mg/l (23 wells; 6%)
- greater than 20 mg/l (8 wells; 2%)

307 wells (83%) have nitrate concentration LESS than the 7 mg/l GWMA trigger level.

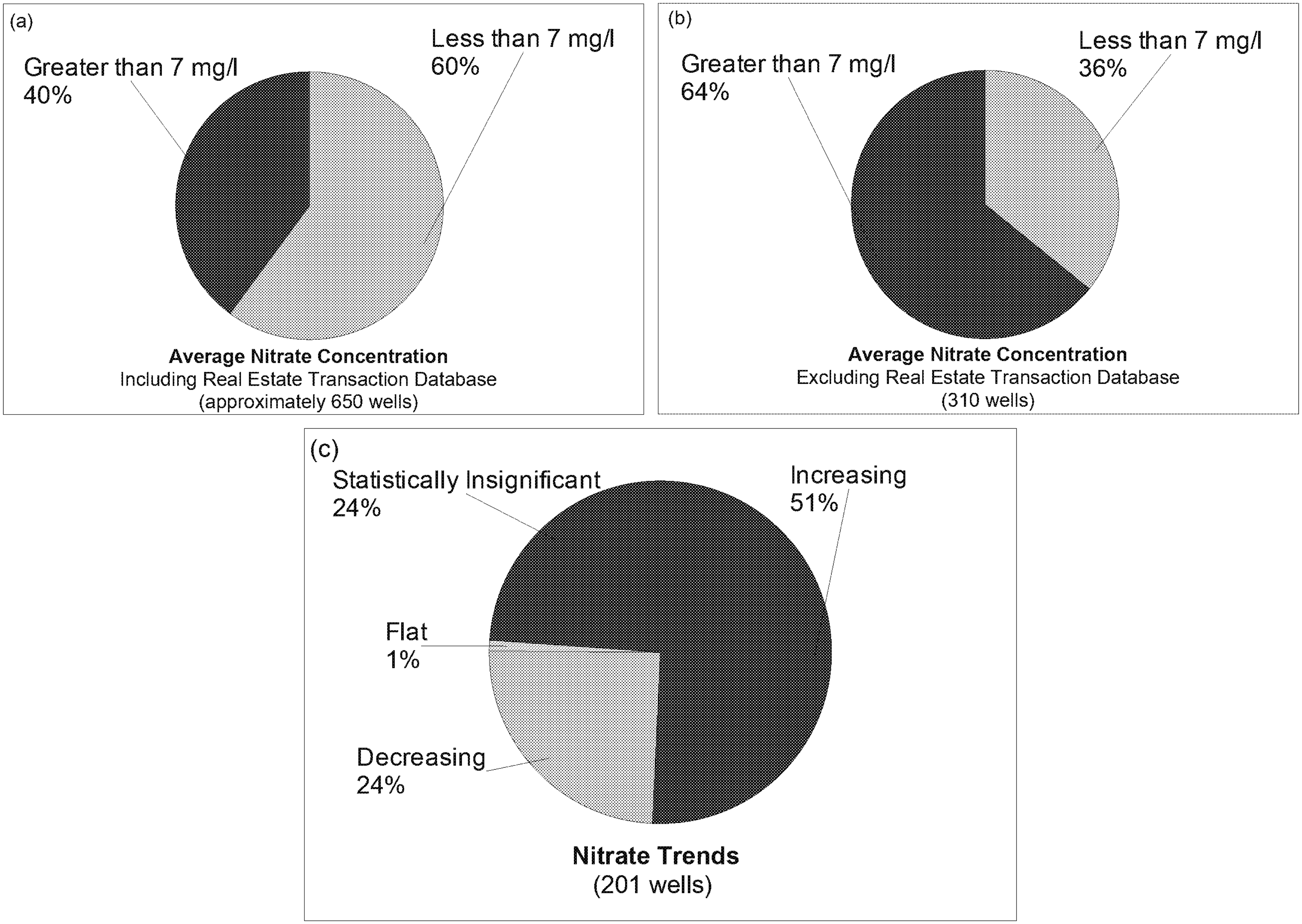
65 wells (17%) have a nitrate concentration GREATER than the 7 mg/l trigger level.



It was not possible to directly determine if wells in this database tap the alluvial aquifer or the deeper basalt aquifer.

0 2 4 8 12 16 Miles

Figure 10-1
Summary of Nitrate Concentrations and Trends at Individual Wells
Analysis of Groundwater Nitrate Concentrations in the LUB GWMA

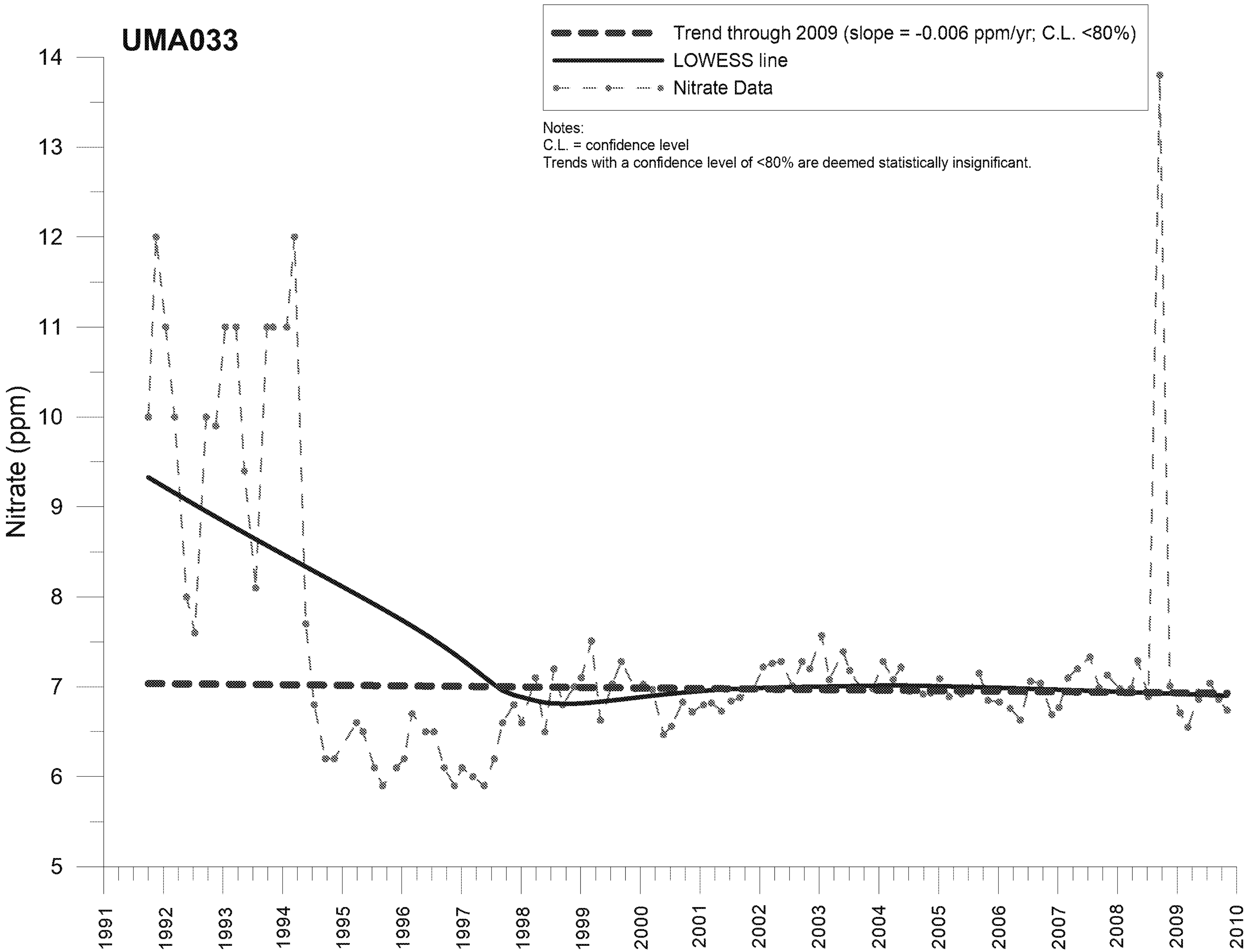


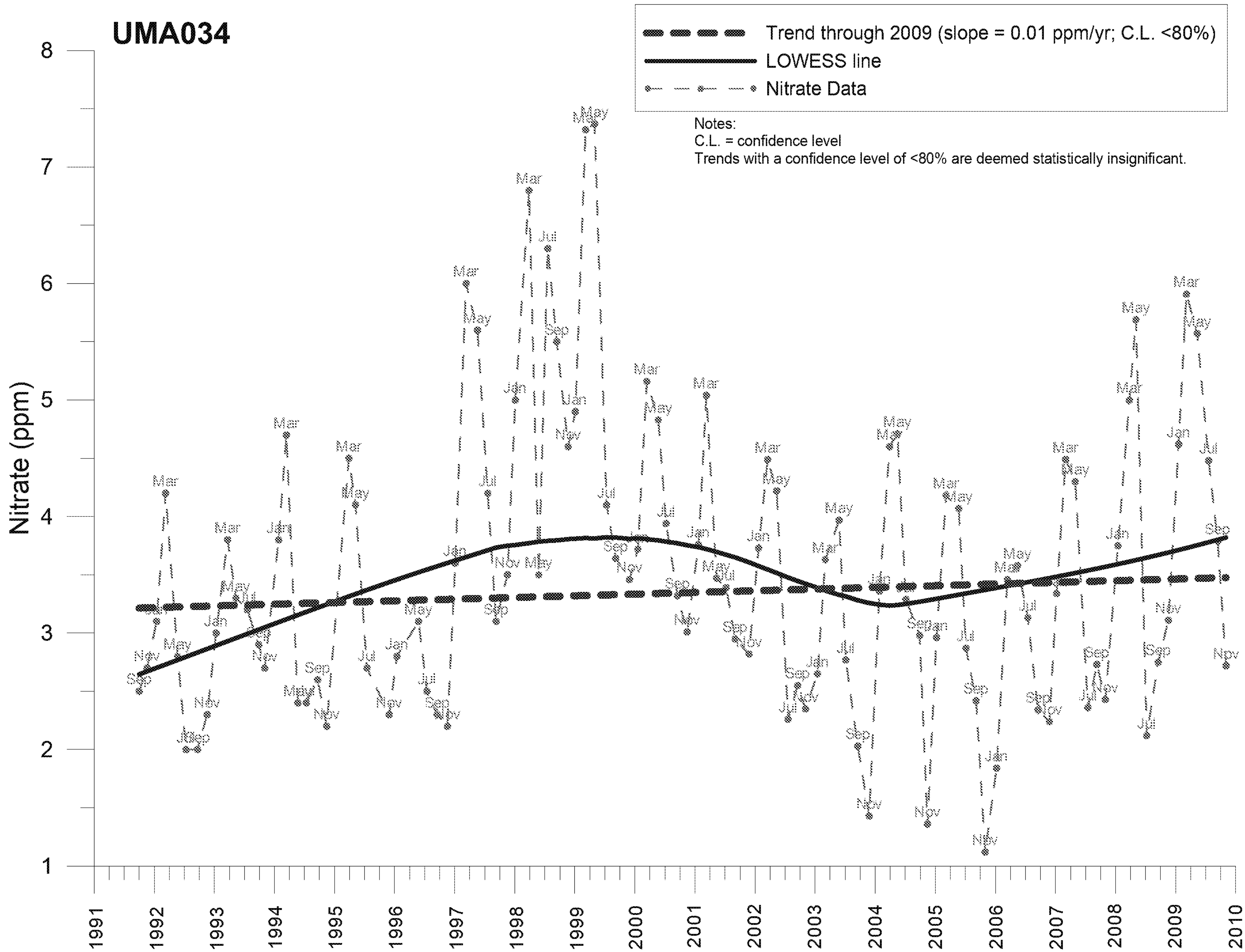
Notes:
(1) Because some of the 372 wells included in the RET database are likely tapping the basalt aquifer (which is typically lower in nitrate concentration), the percentage of alluvial aquifer wells with average nitrate concentration greater than 7 mg/l is likely higher than 40%.

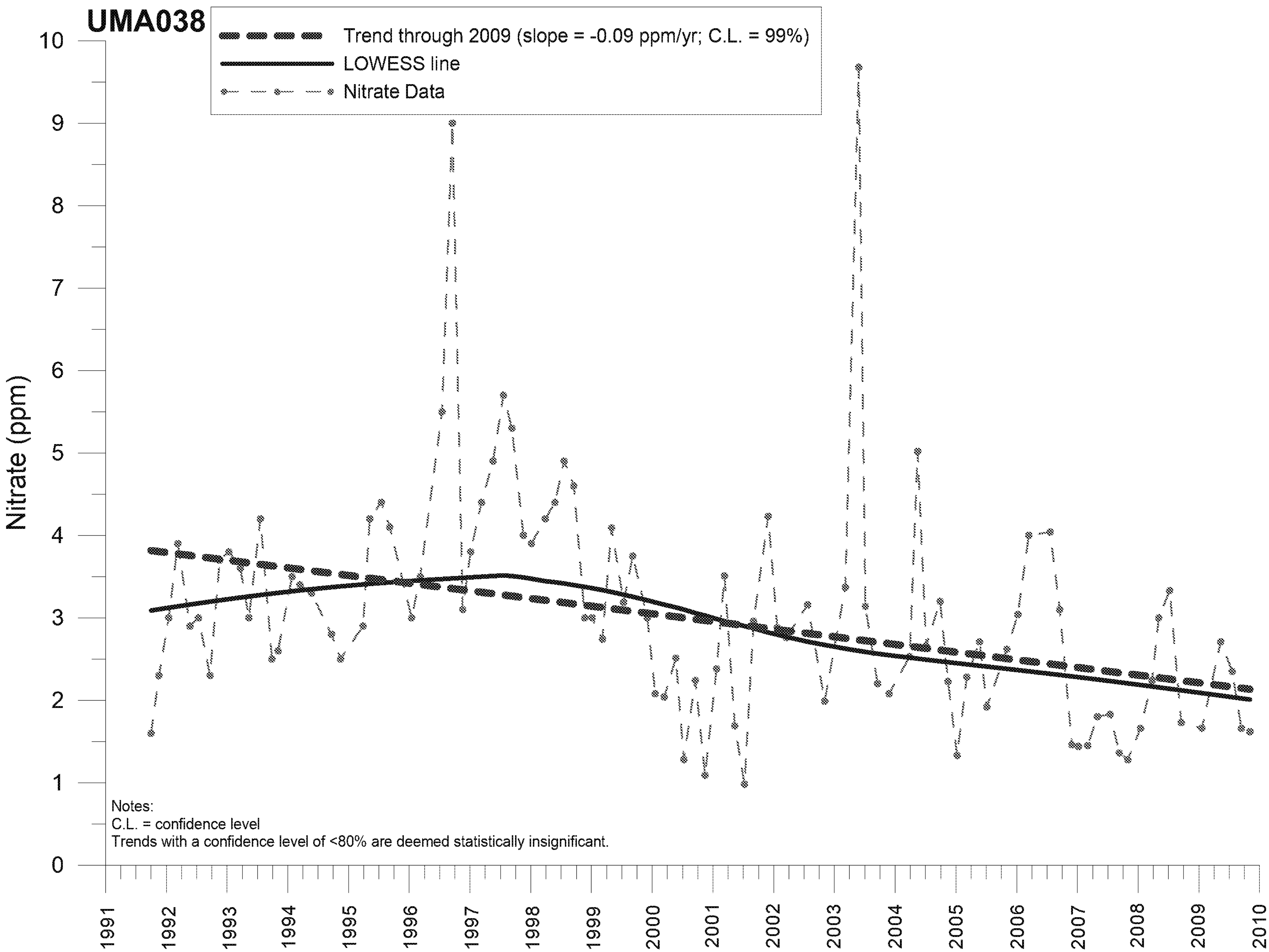
(2) Average nitrate values were used for regularly sampled wells. Otherwise, individual nitrate concentrations were used.

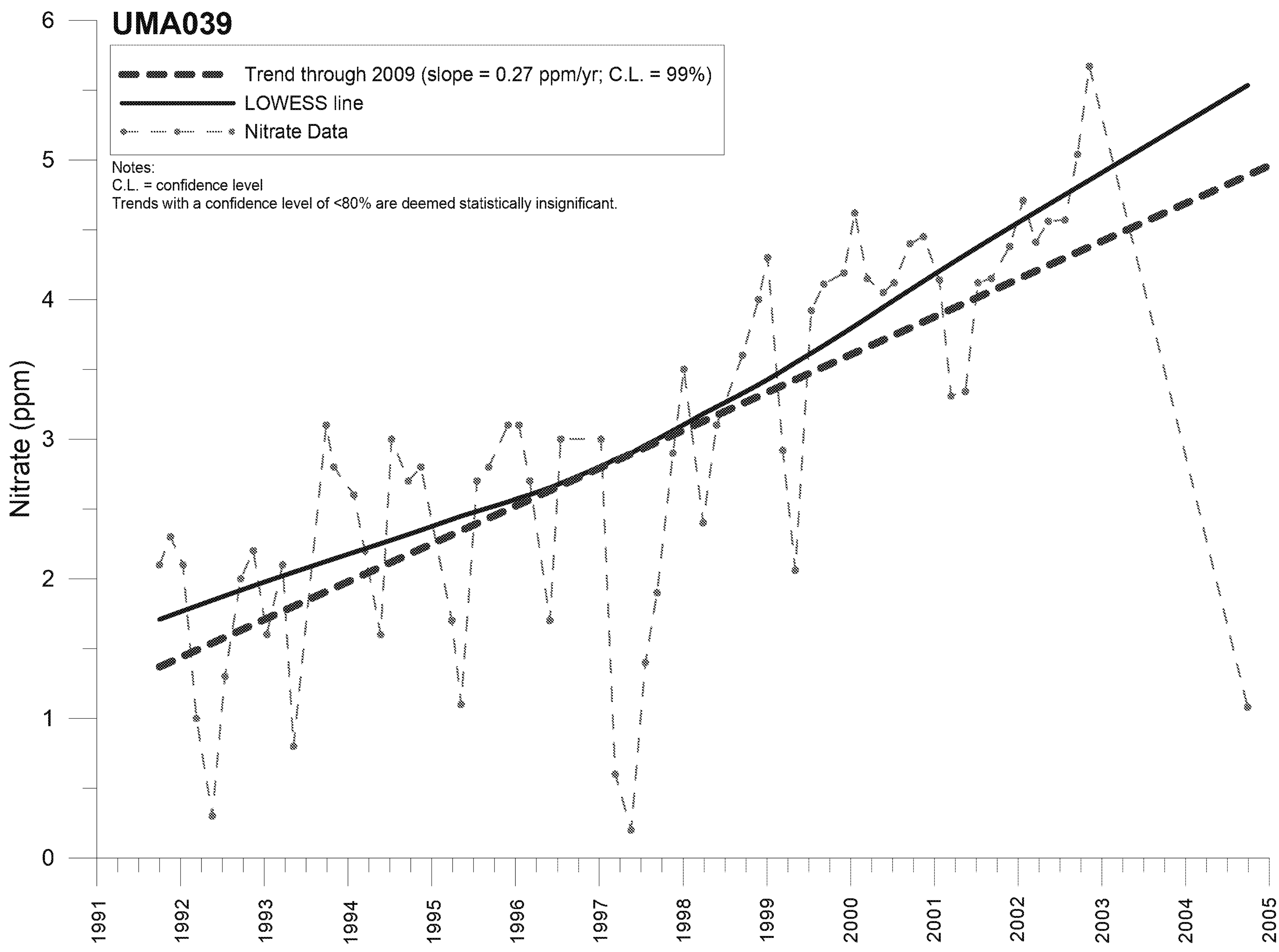
Appendix A

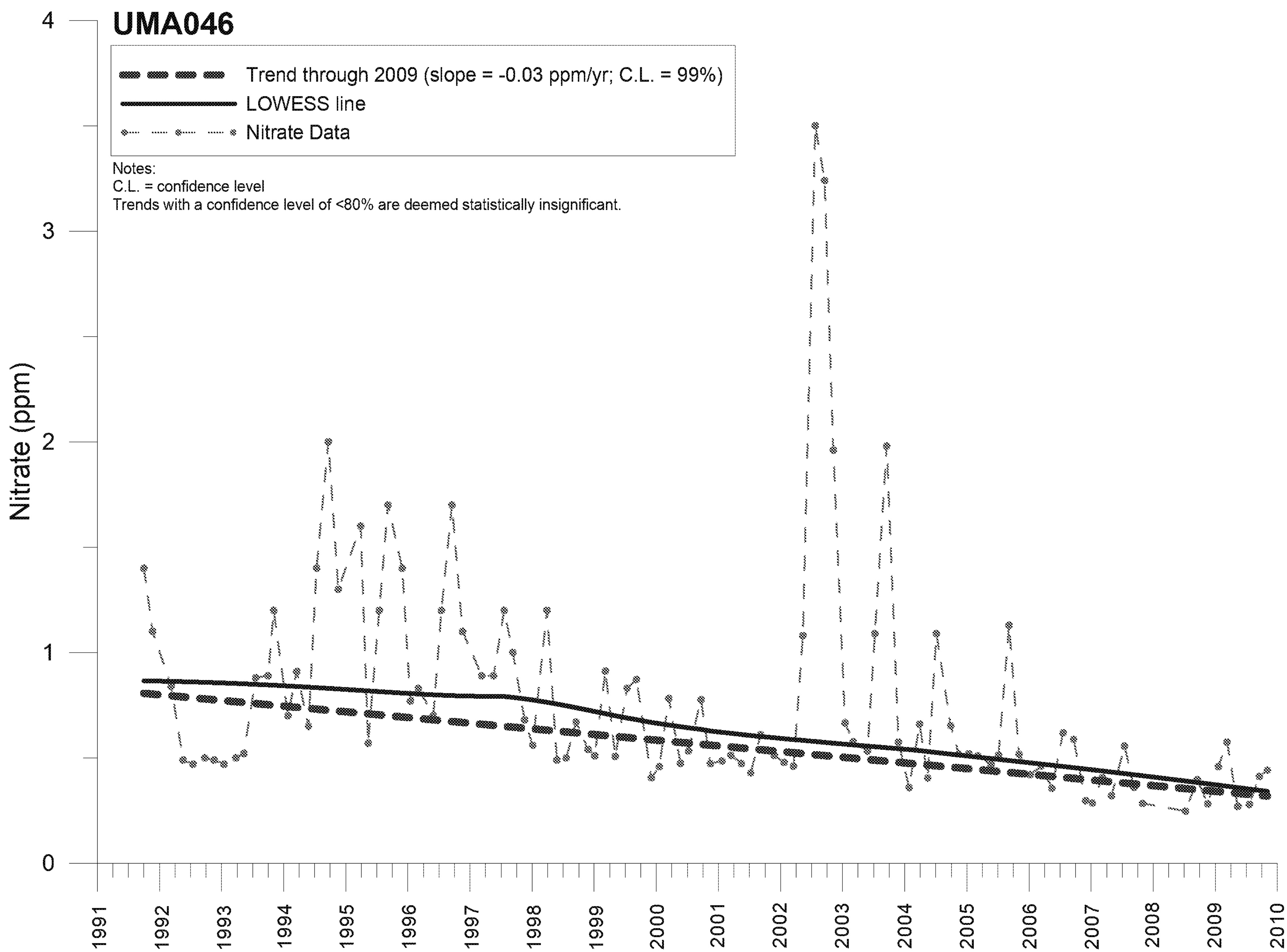
Time Series Plots for LUB GWMA Well Network

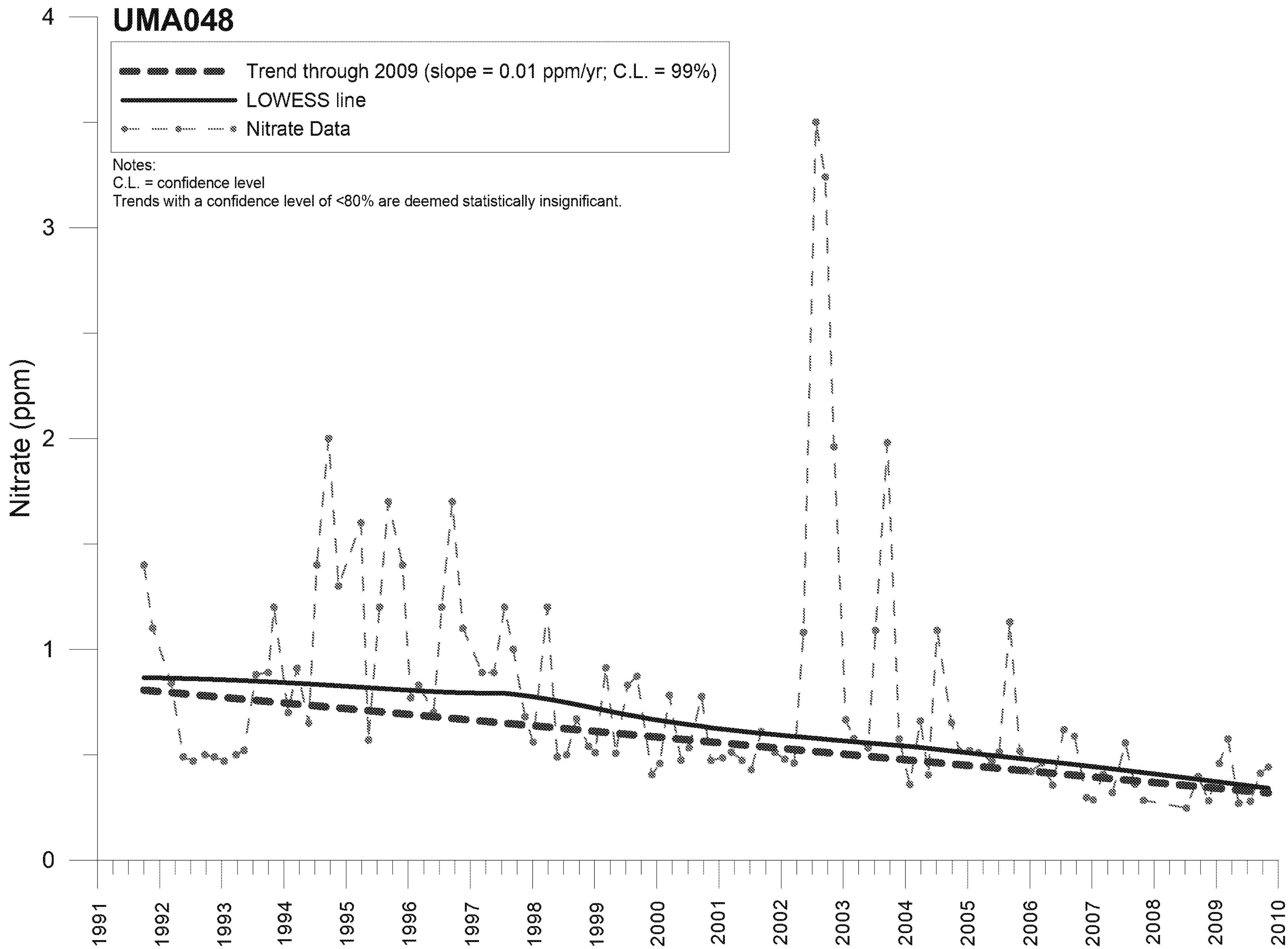

UMA033
Trend through 2009 (slope = -0.006 ppm/yr; C.L. <80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


UMA034
Trend through 2009 (slope = 0.01 ppm/yr; C.L. <80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
1
2
3
4
5
6
7
8
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

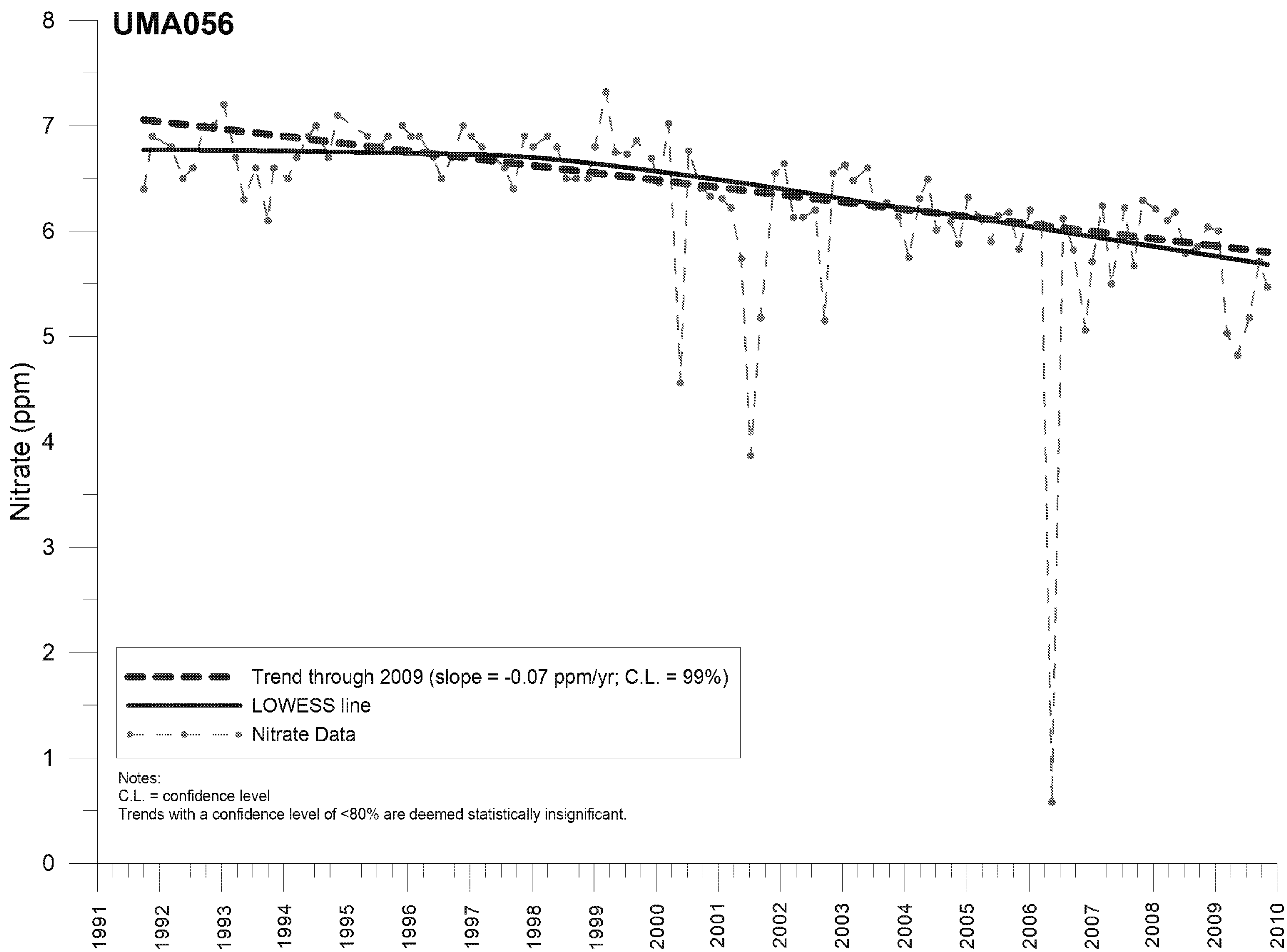

UMA038
Trend through 2009 (slope = -0.09 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


UMA039
Trend through 2009 (slope = 0.27 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005

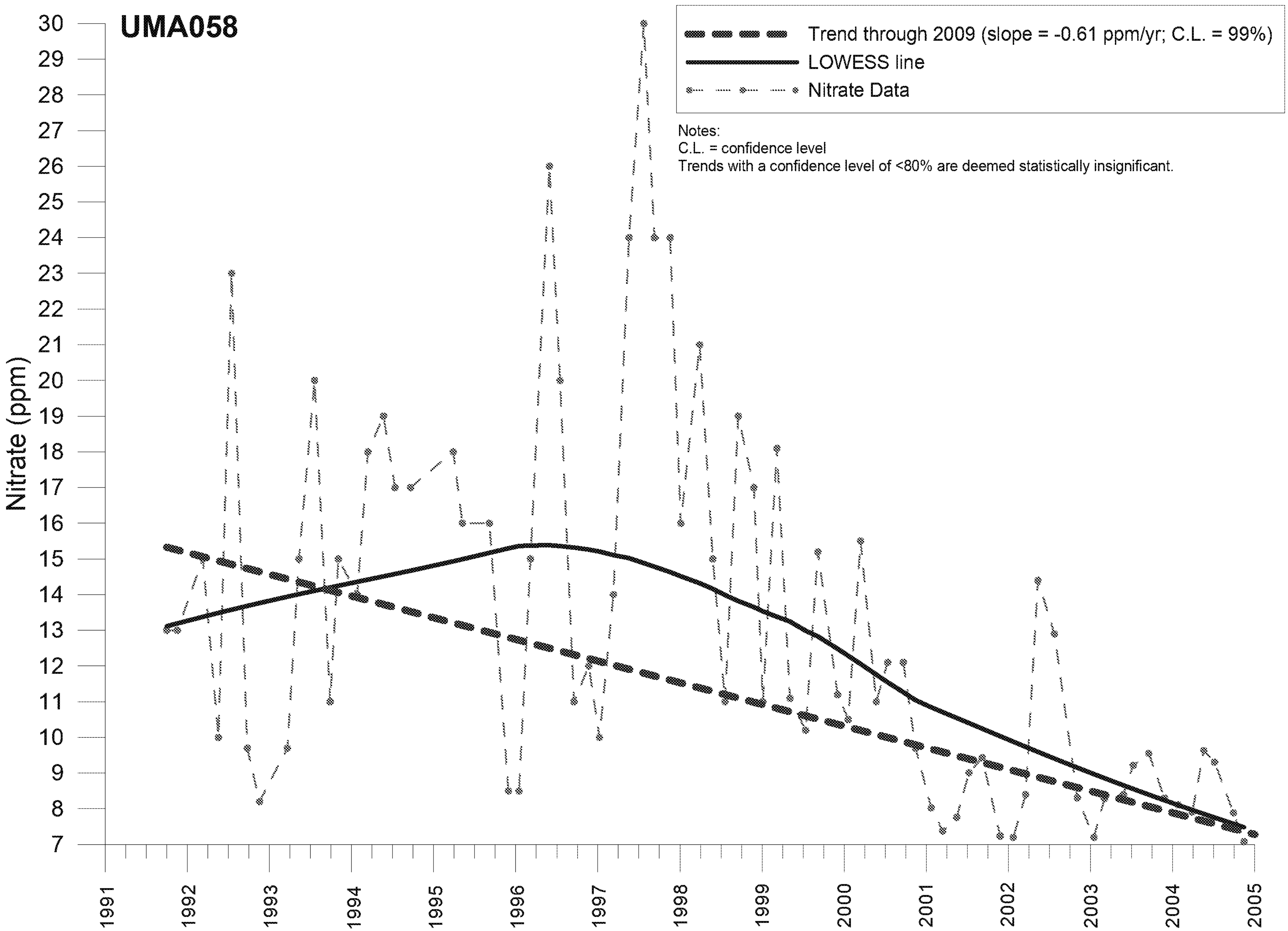

UMA046
Trend through 2009 (slope = -0.03 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

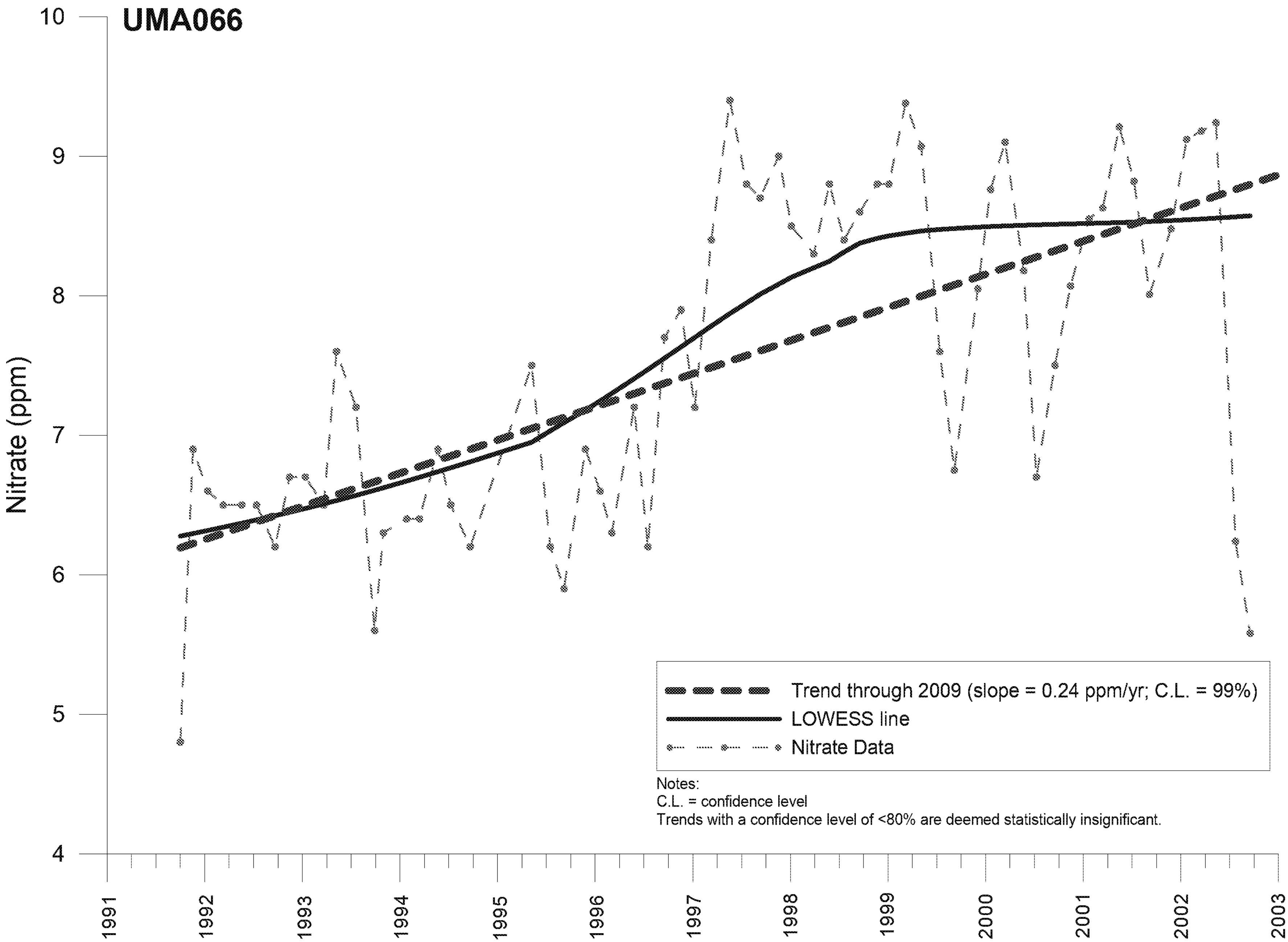


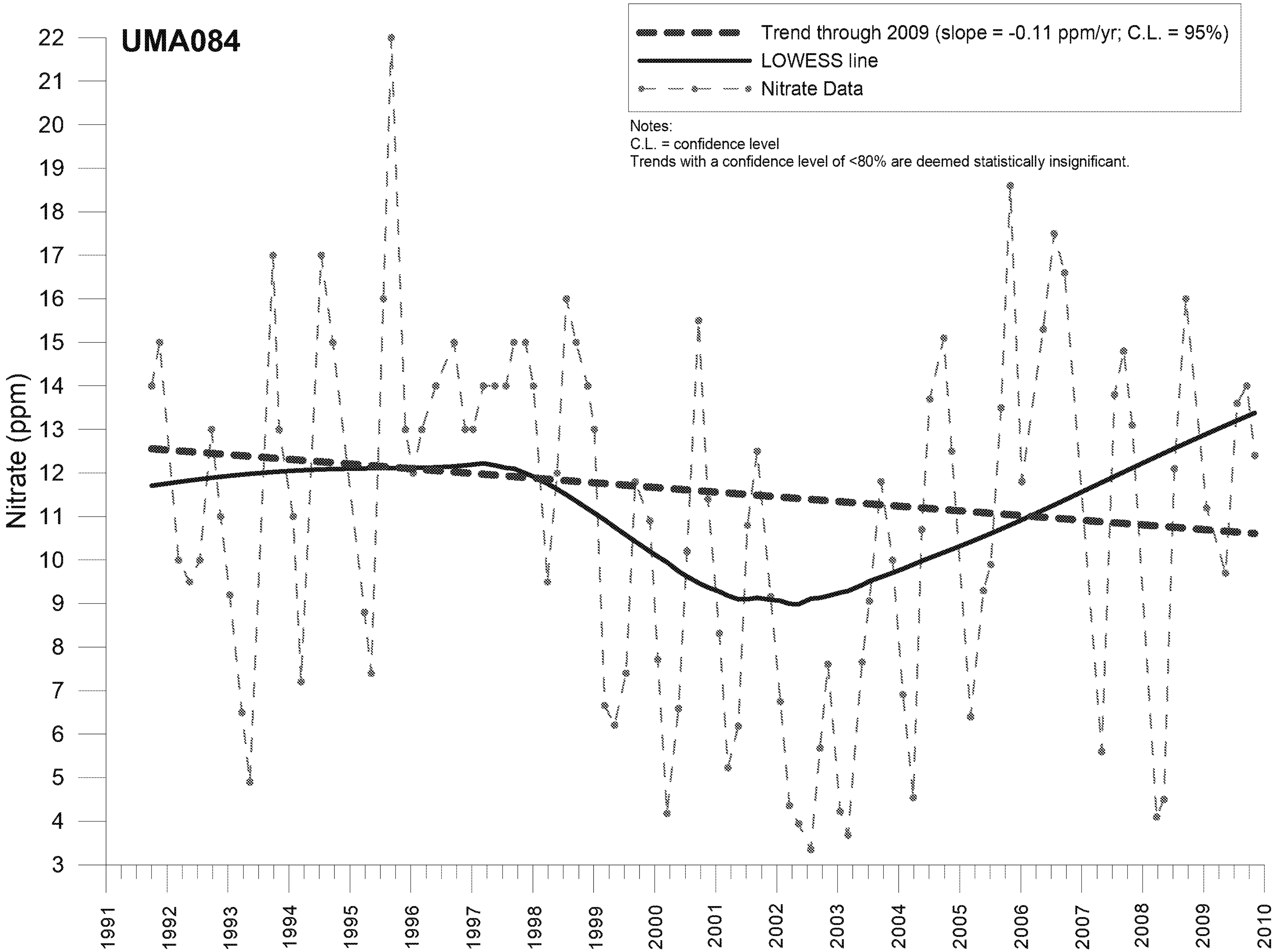
UMA048
Trend through 2009 (slope = 0.01 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



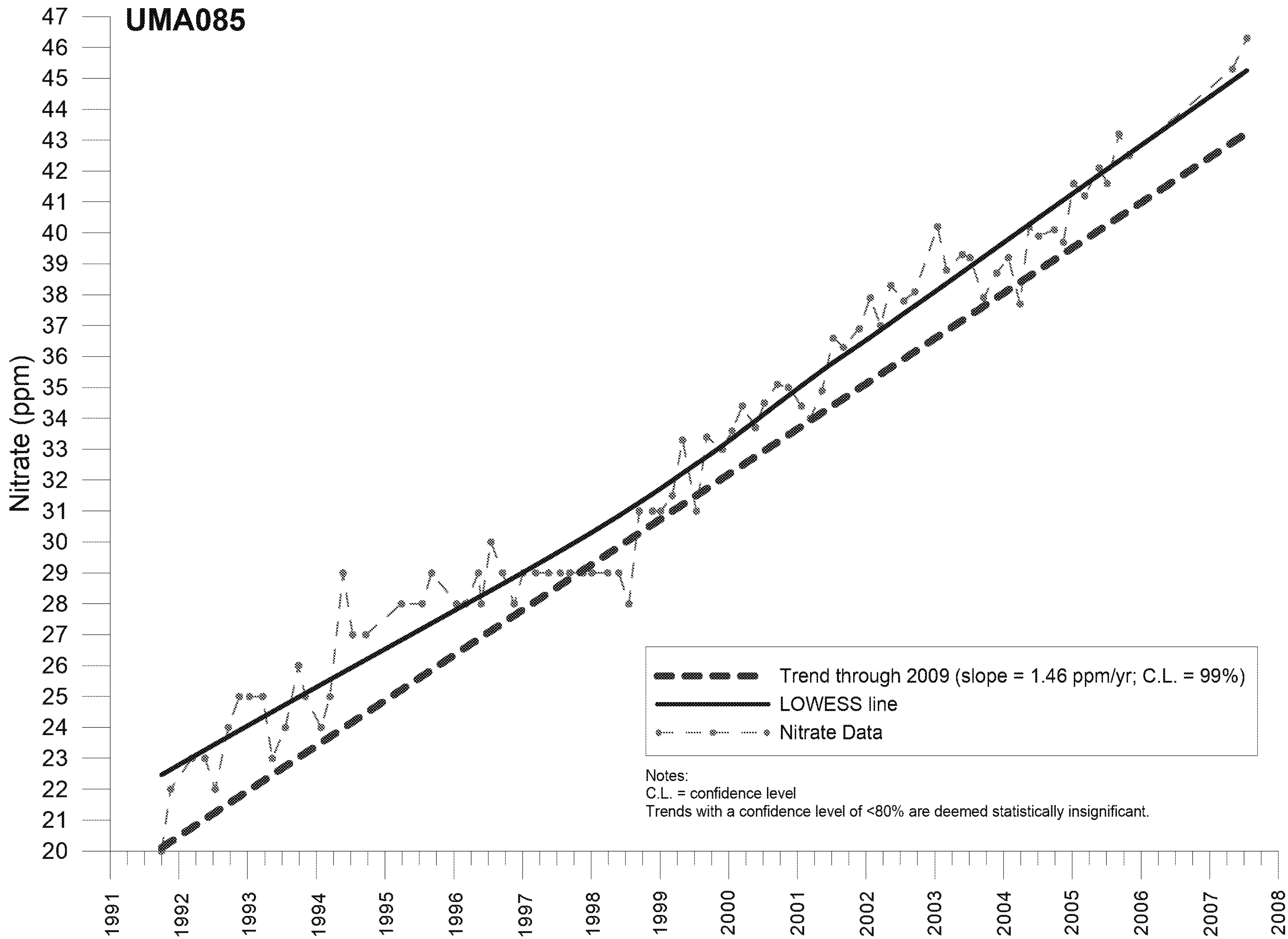
ED_005296_00001040-00080

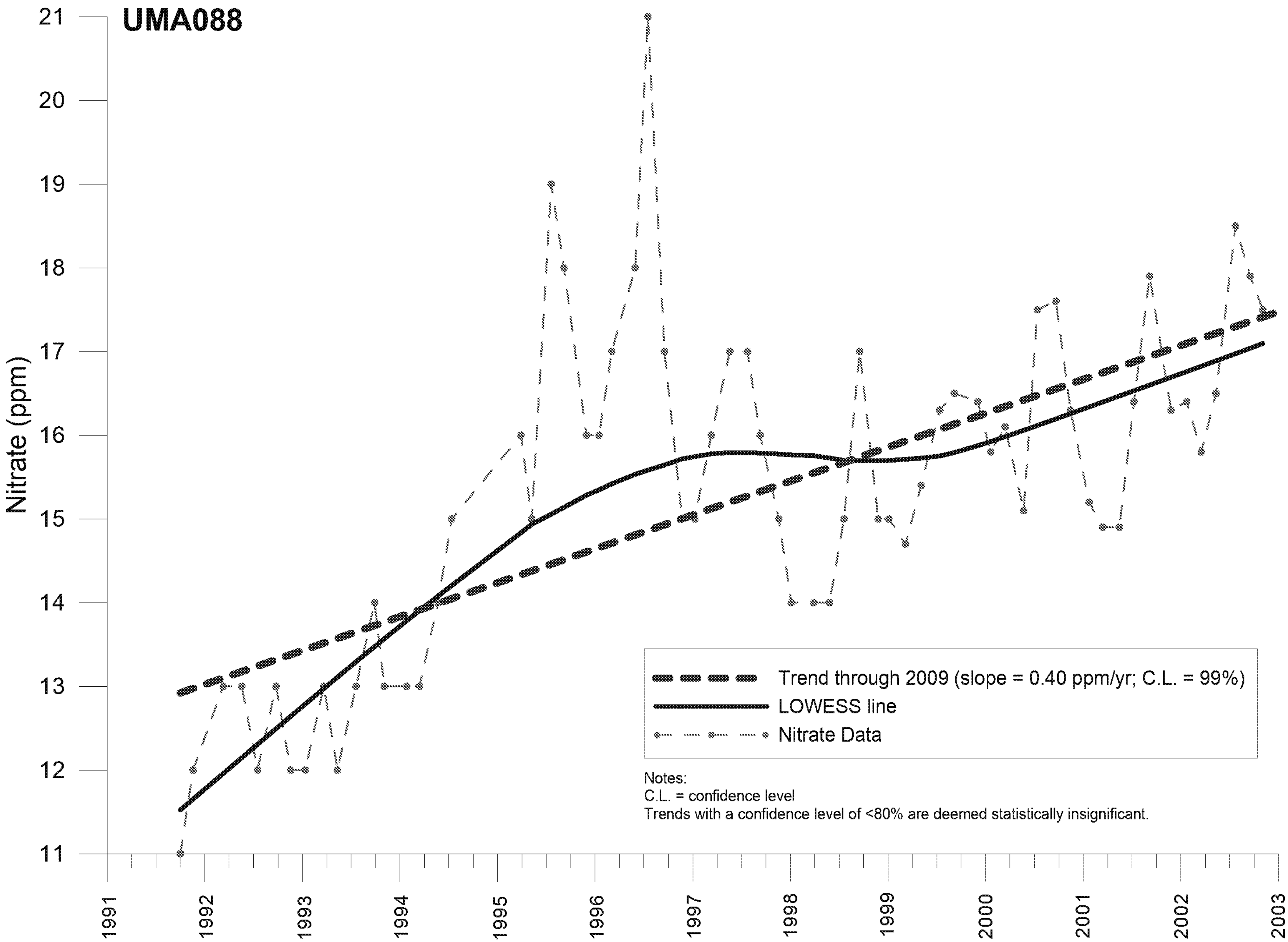

UMA058
Trend through 2009 (slope = -0.61 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005


UMA066
Nitrate (ppm)
10
9
8
7
6
5
4
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Trend through 2009 (slope = 0.24 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

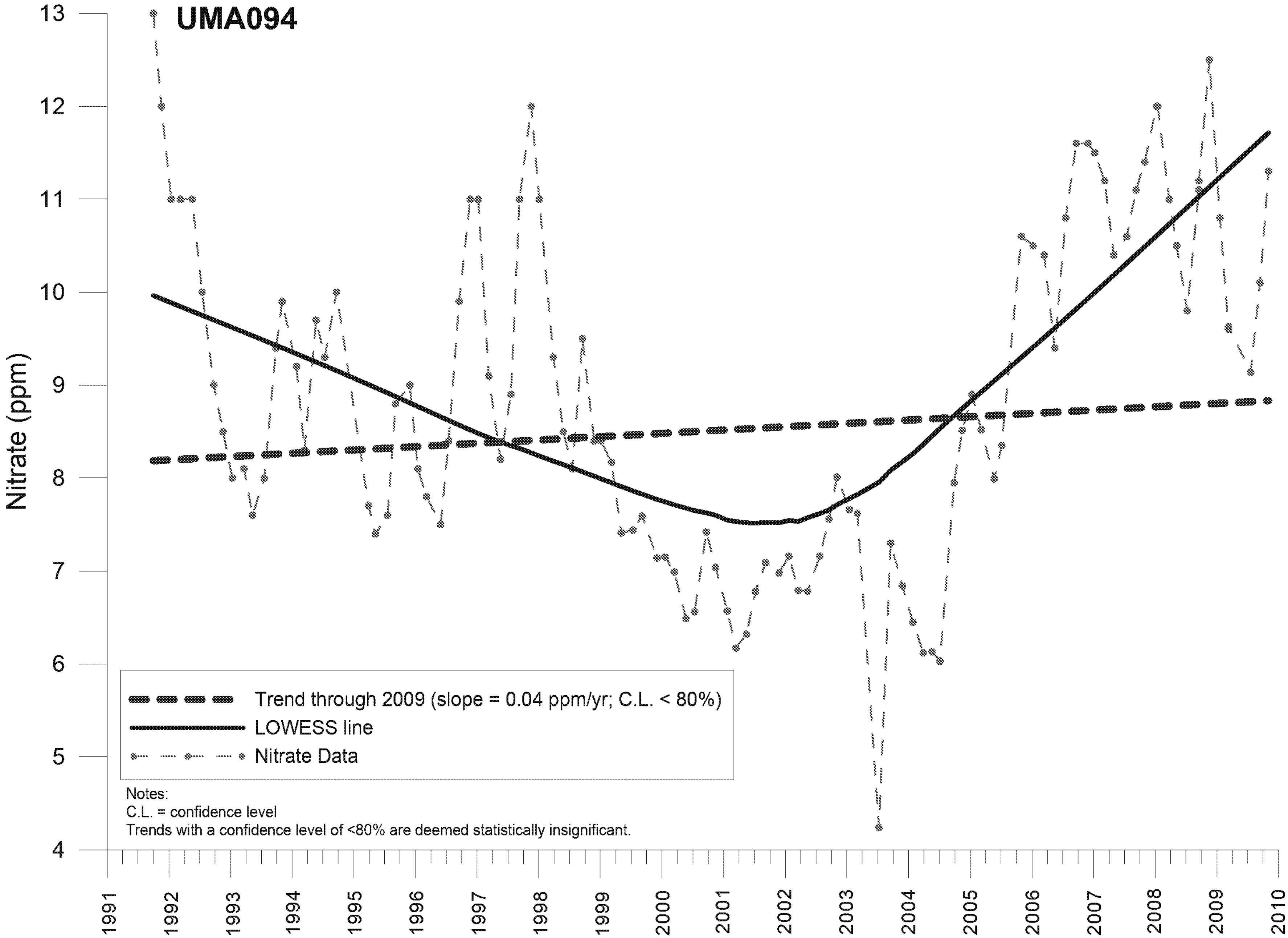


UMA084
Trend through 2009 (slope = -0.11 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

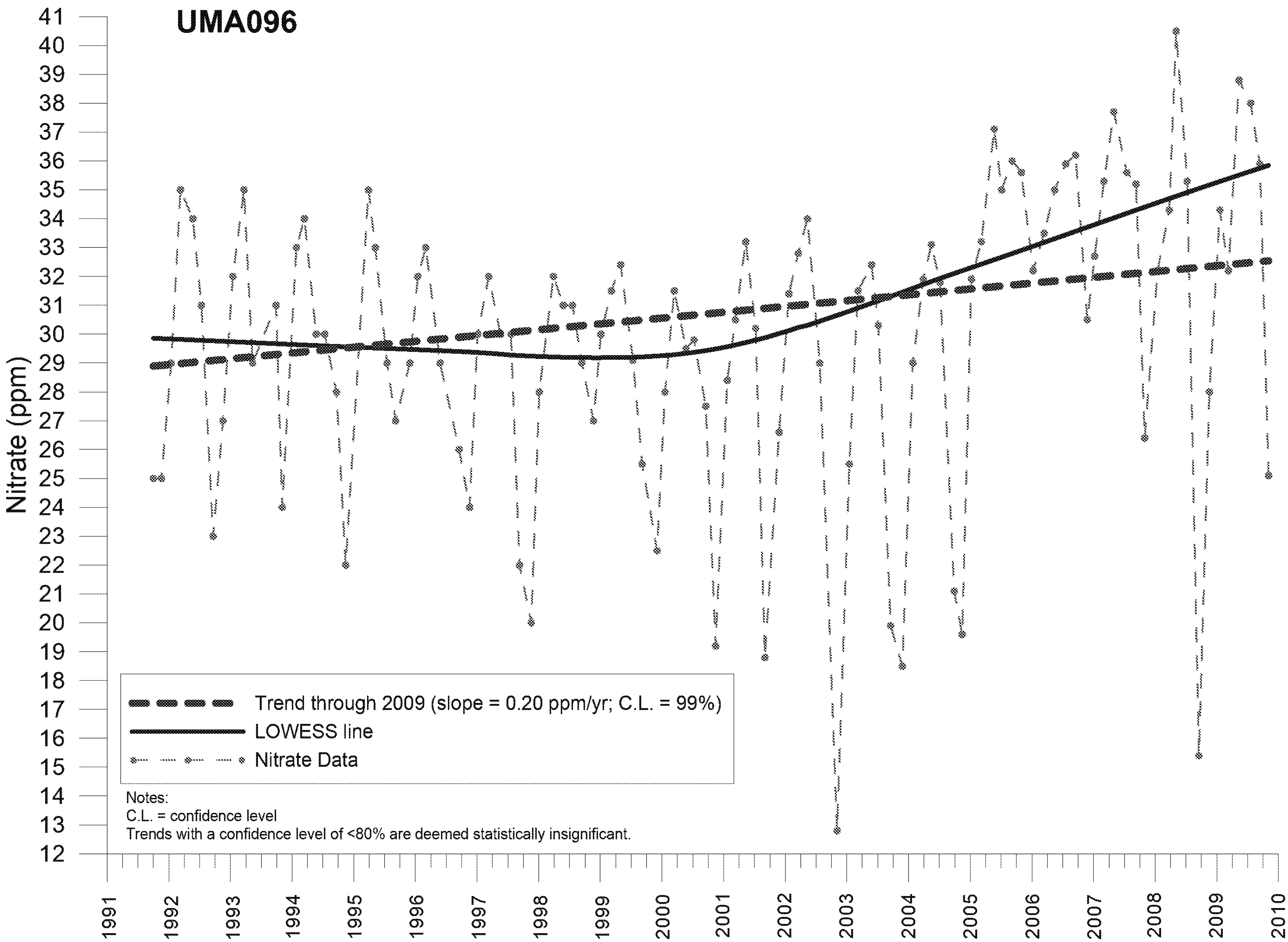

UMA085
Nitrate (ppm)
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Trend through 2009 (slope = 1.46 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



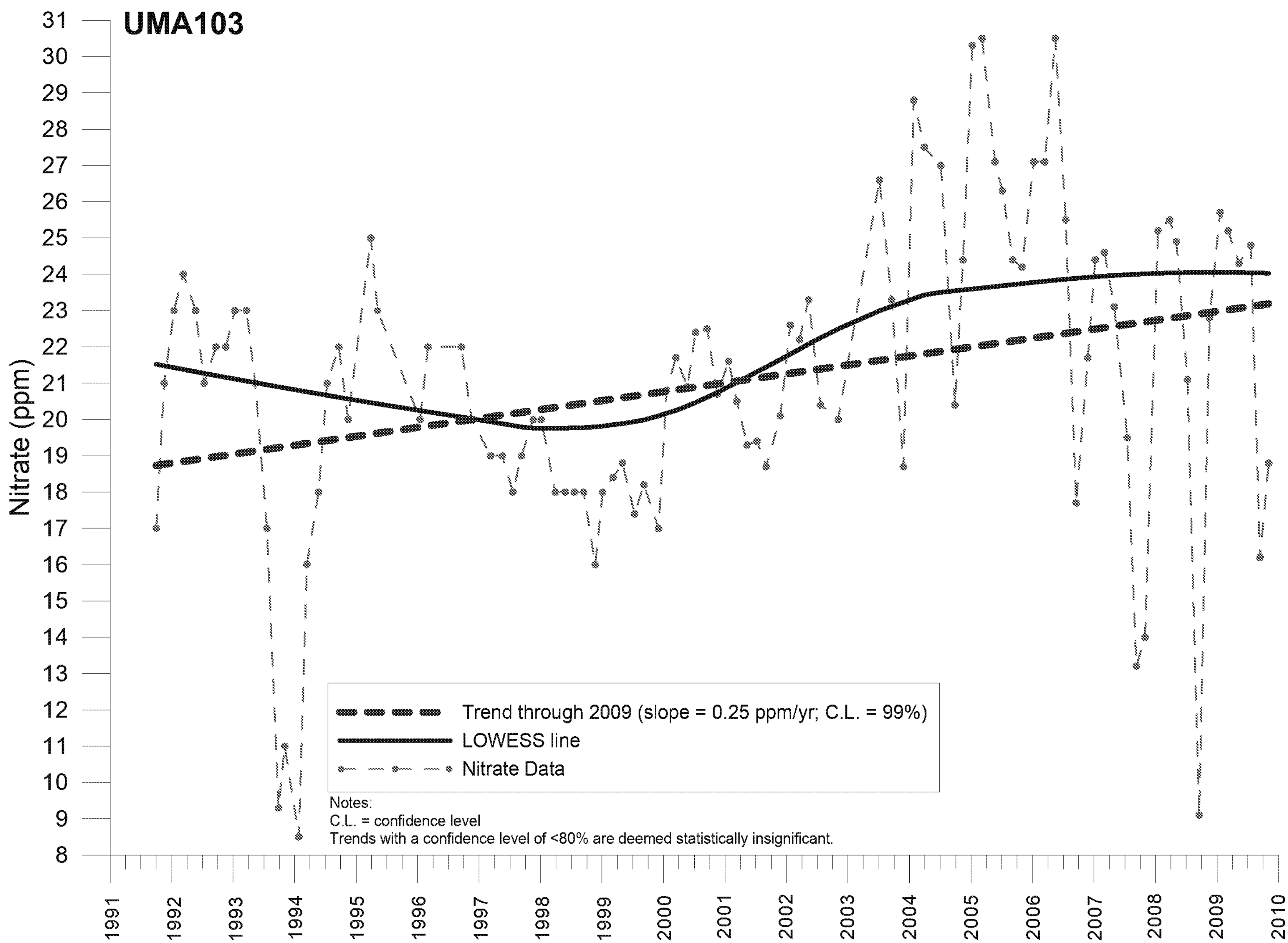
UMA088
Nitrate (ppm)
21
20
19
18
17
16
15
14
13
12
11
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Trend through 2009 (slope = 0.40 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



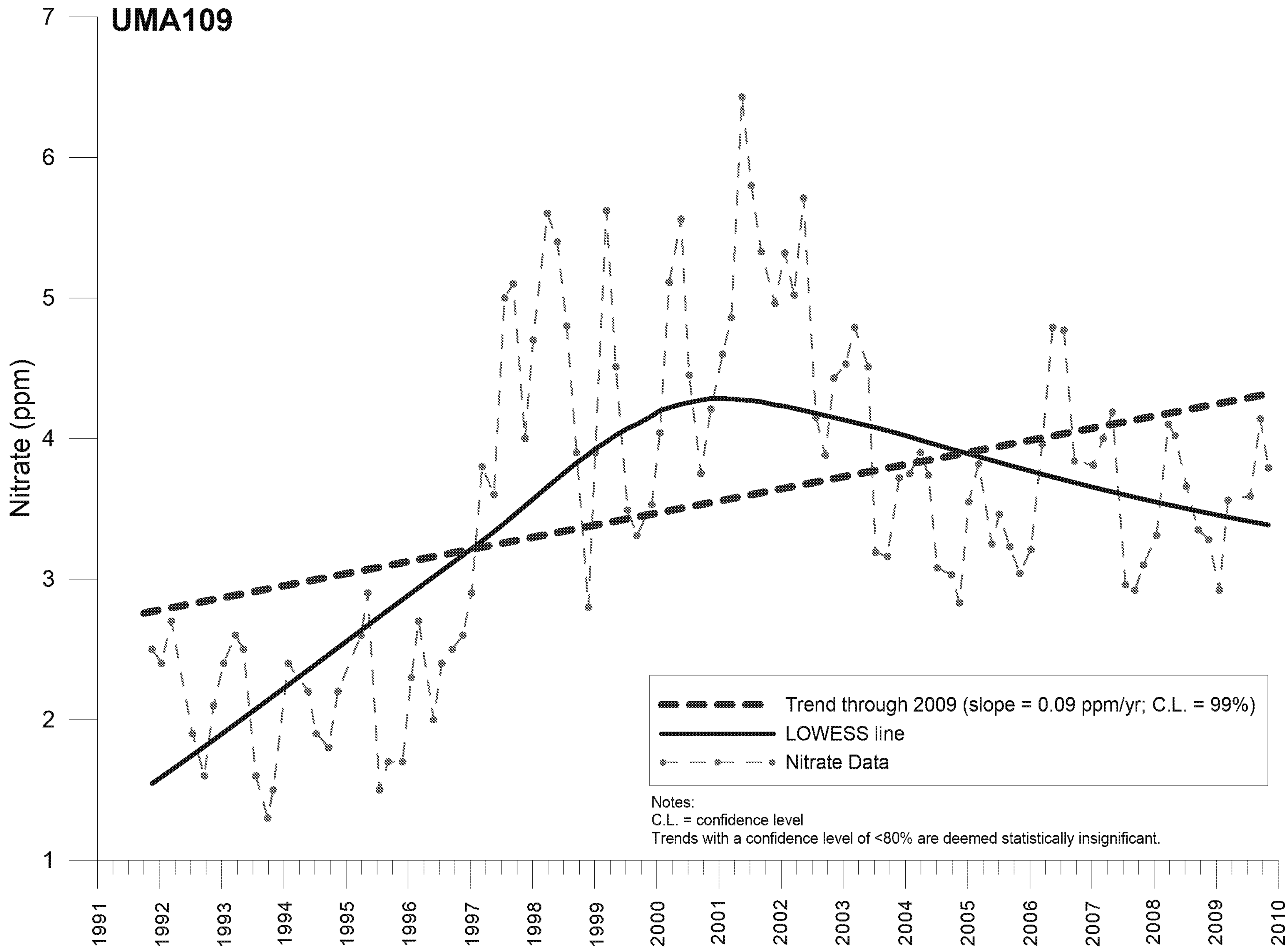
UMA094
Nitrate (ppm)
13
12
11
10
9
8
7
6
5
4
Trend through 2009 (slope = 0.04 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

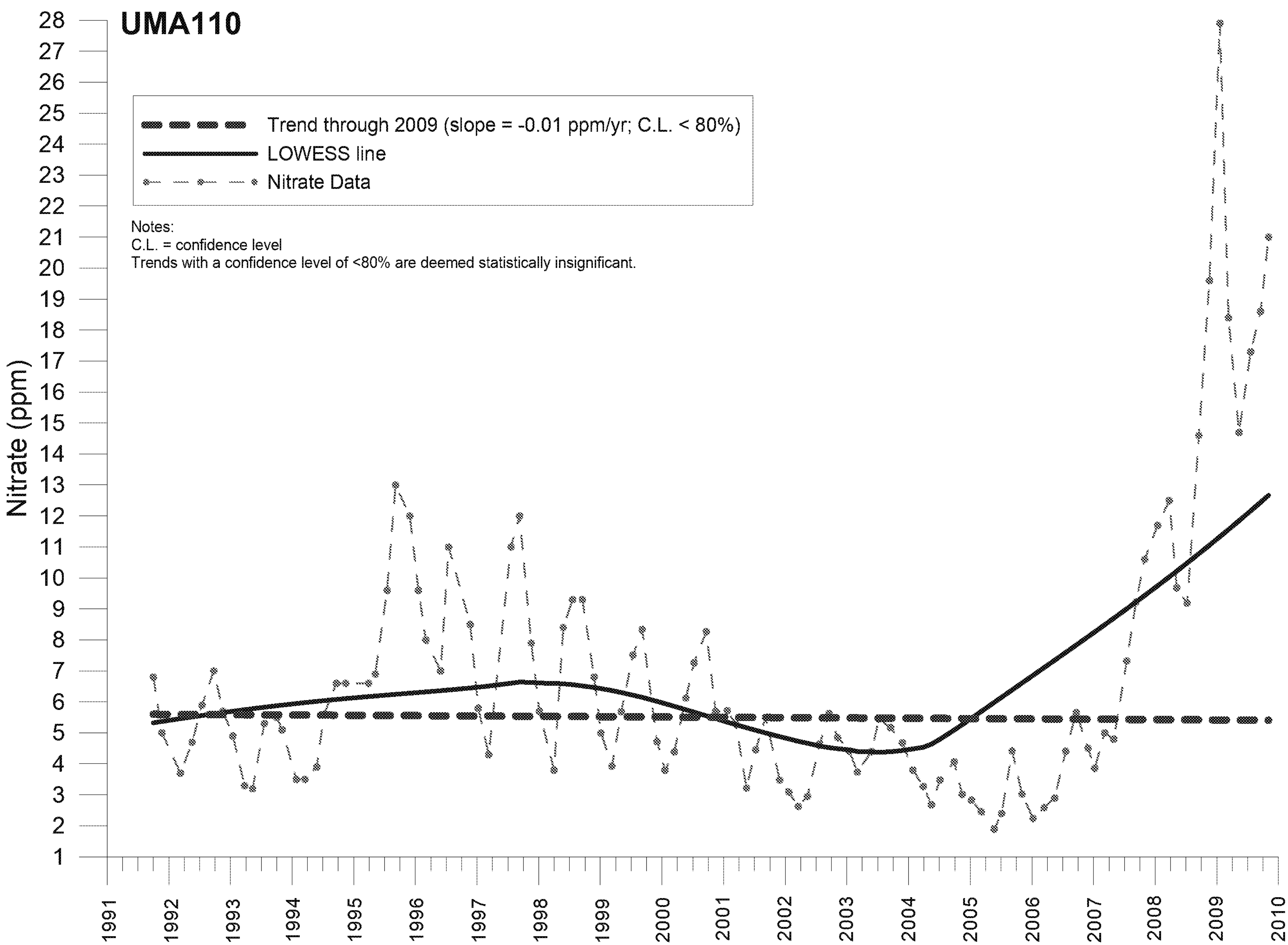


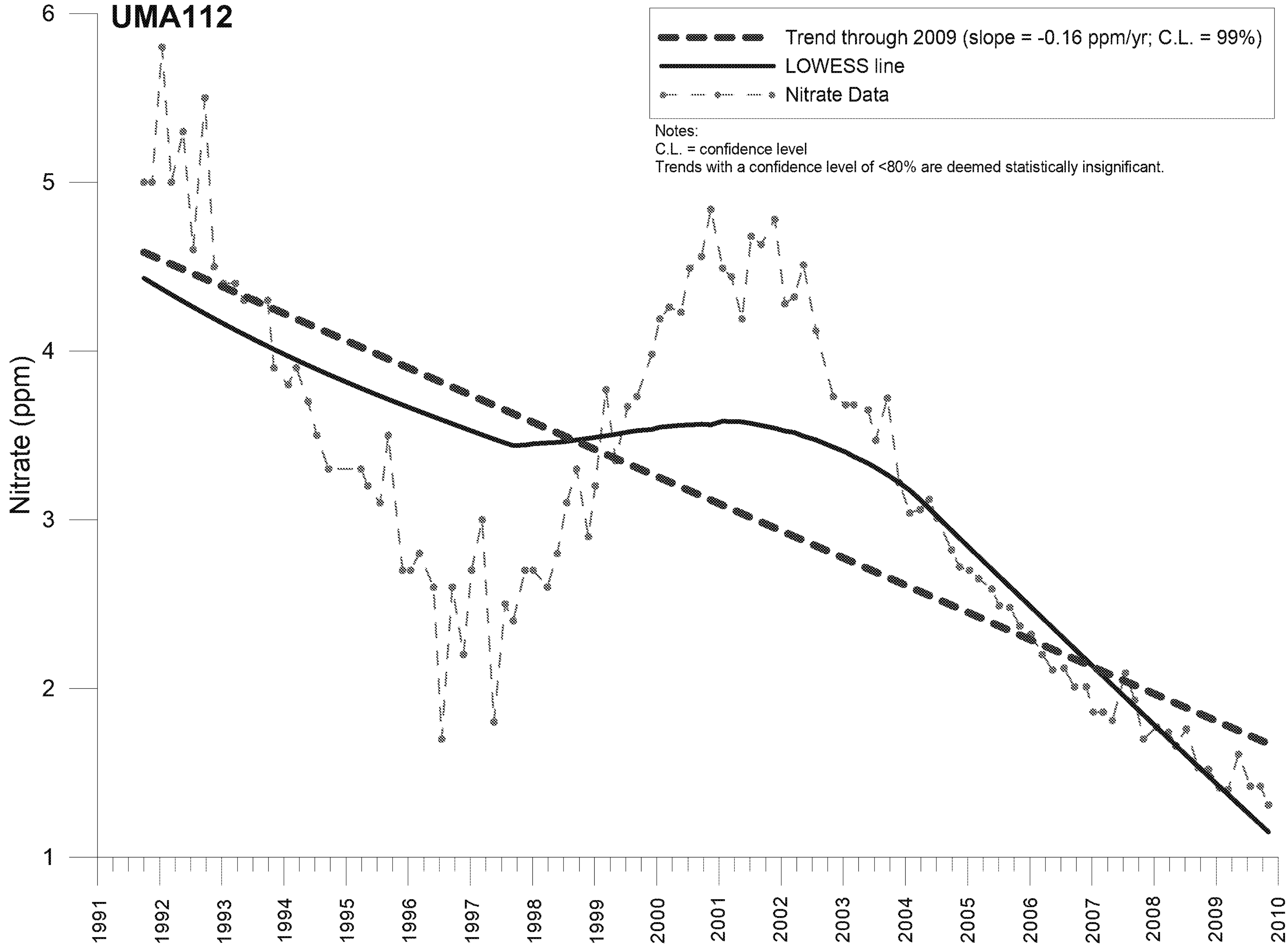
ED_005296_00001040-00087



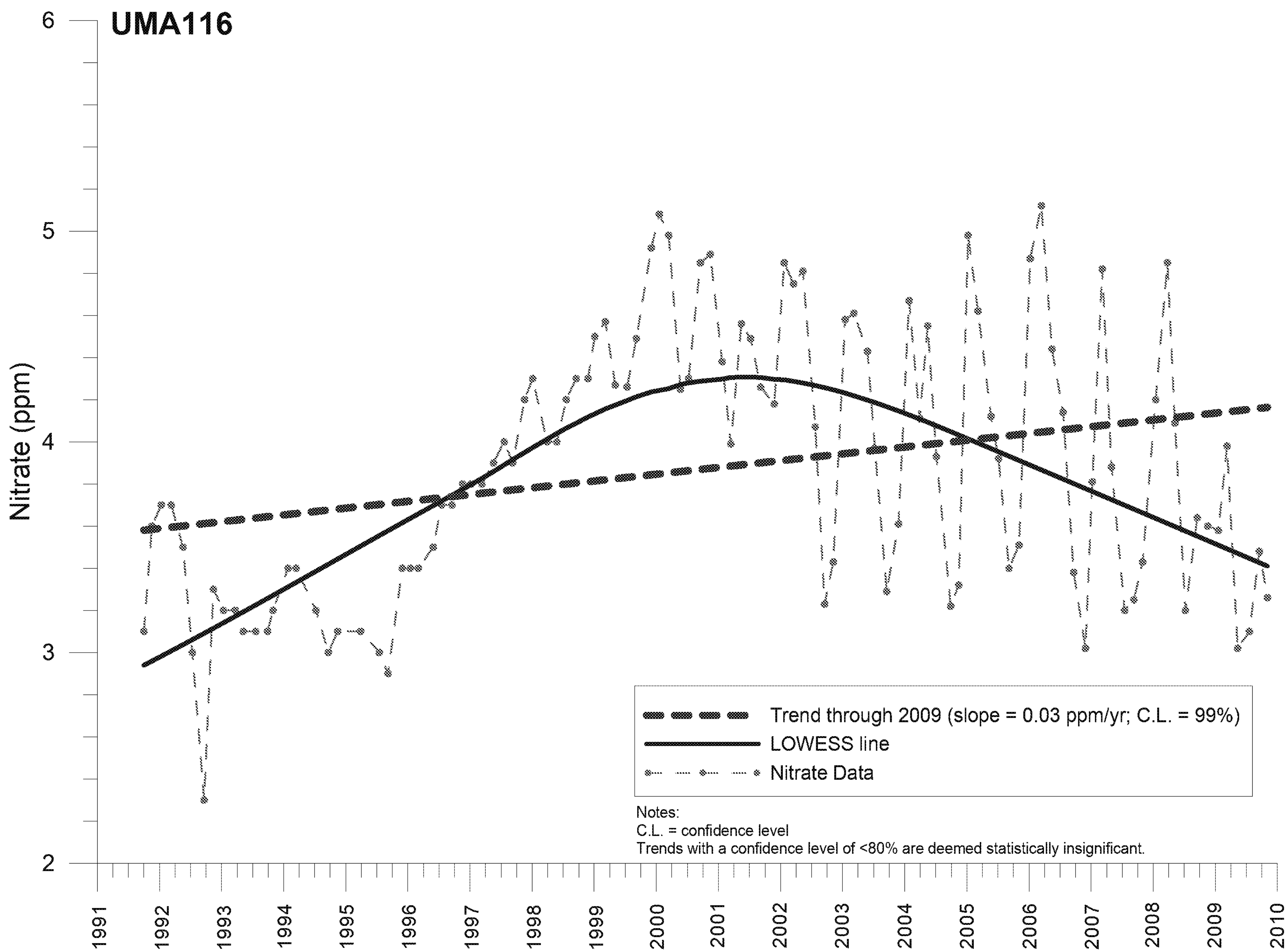
UMA103
Nitrate (ppm)
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
Trend through 2009 (slope = 0.25 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

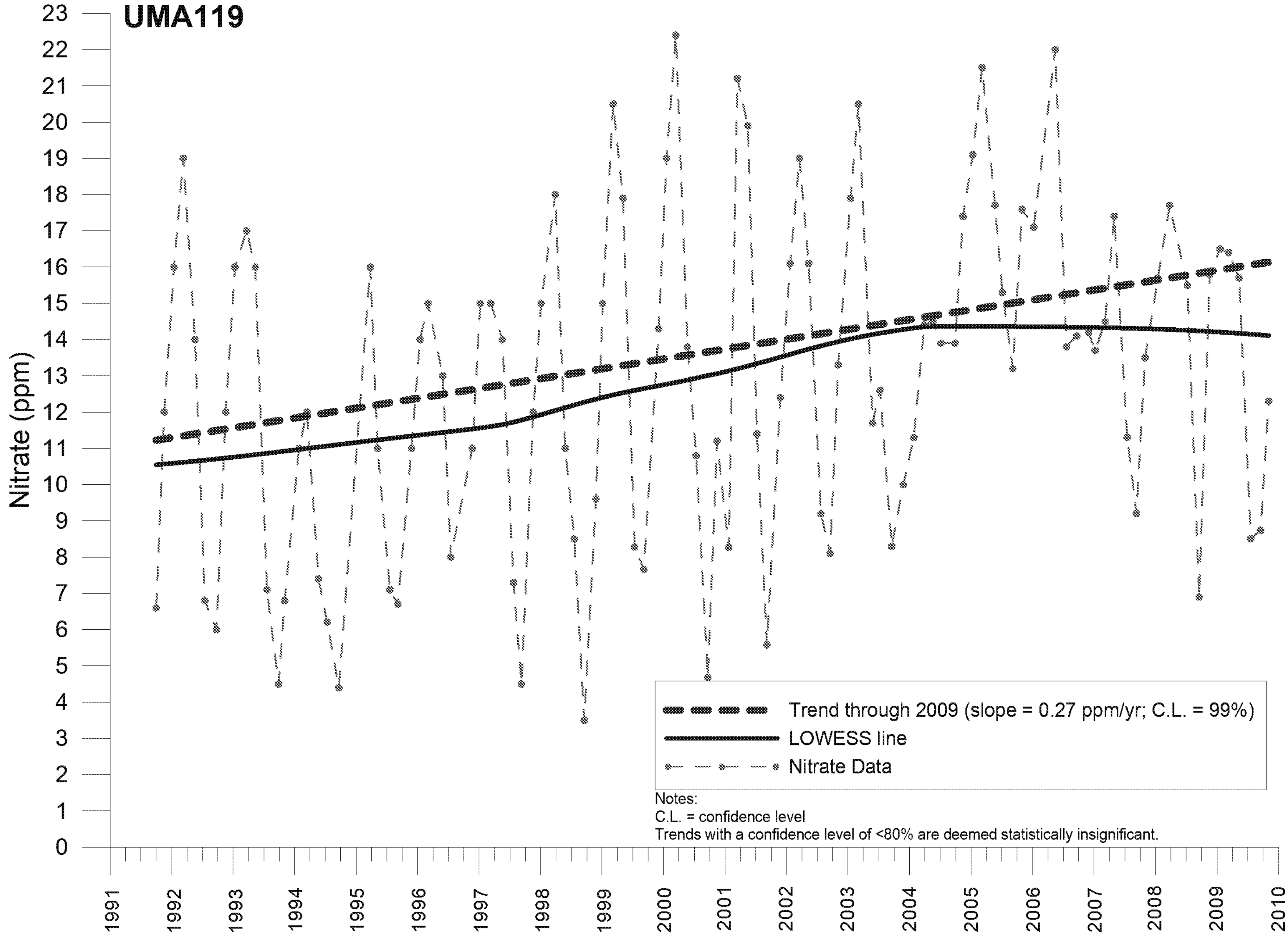

UMA109
Nitrate (ppm)
1
2
3
4
5
6
7
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.09 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

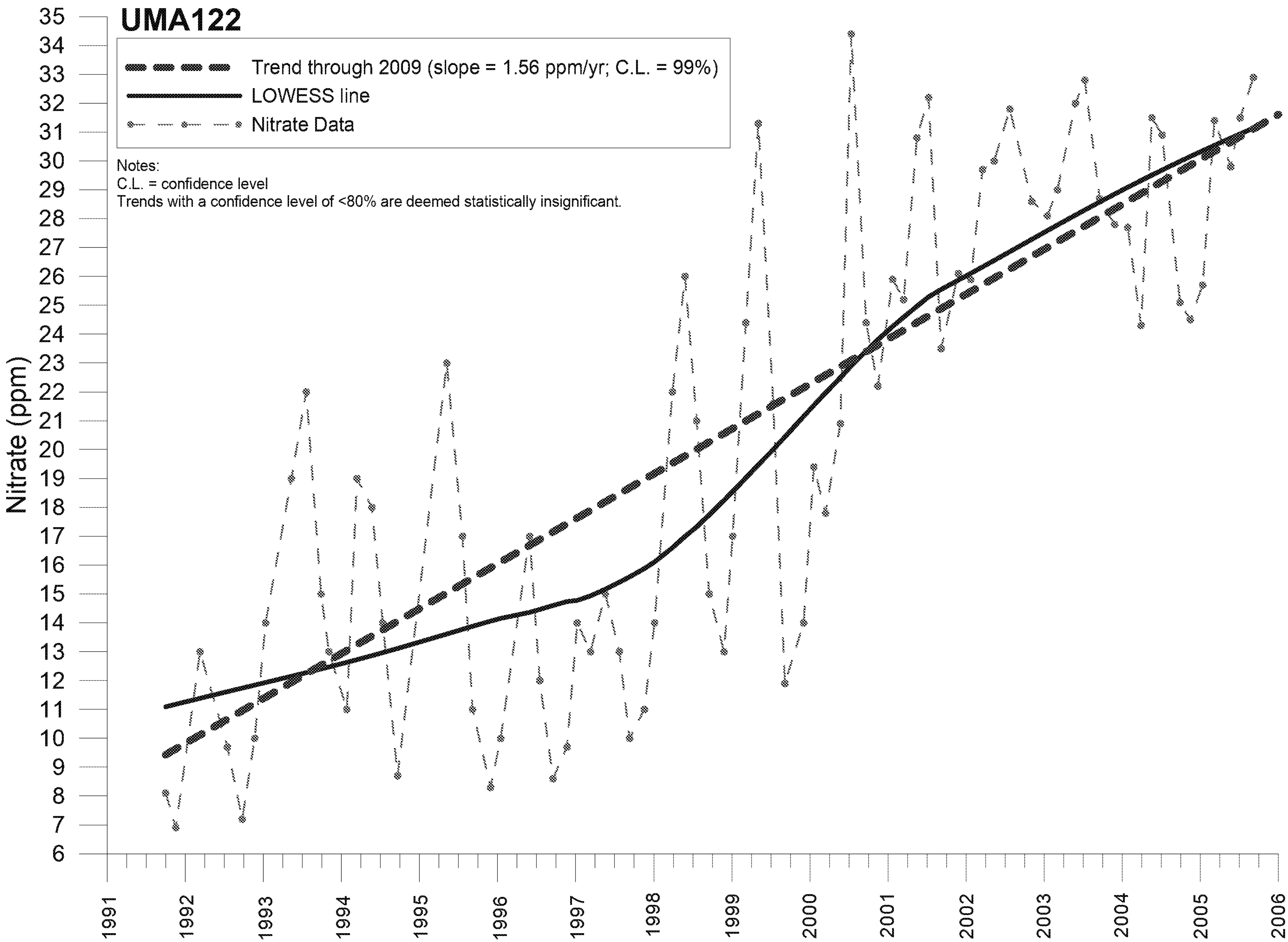

UMA110
Trend through 2009 (slope = -0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



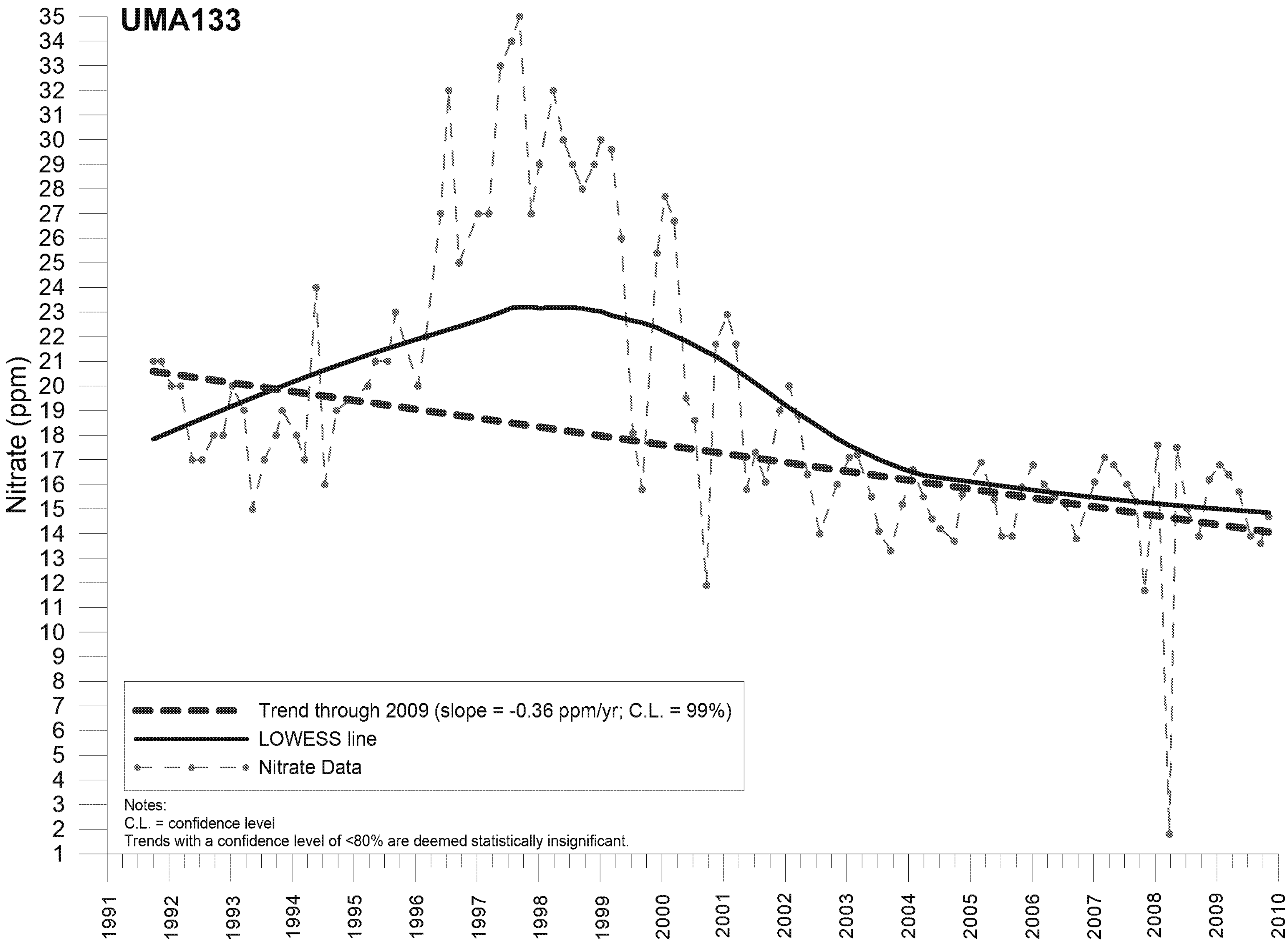
ED_005296_00001040-00091

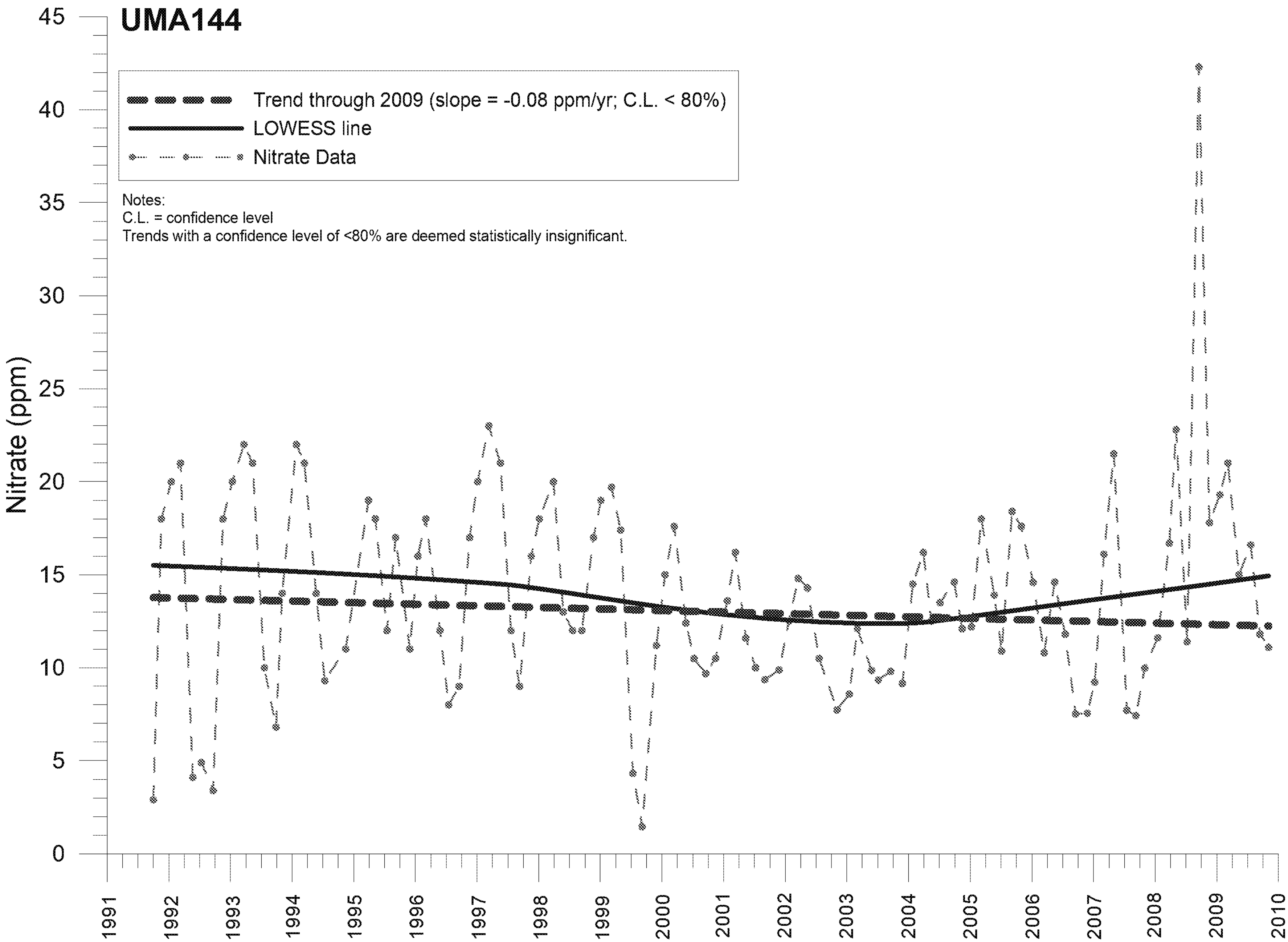

UMA116
6
5
4
3
2
Nitrate (ppm)
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.03 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

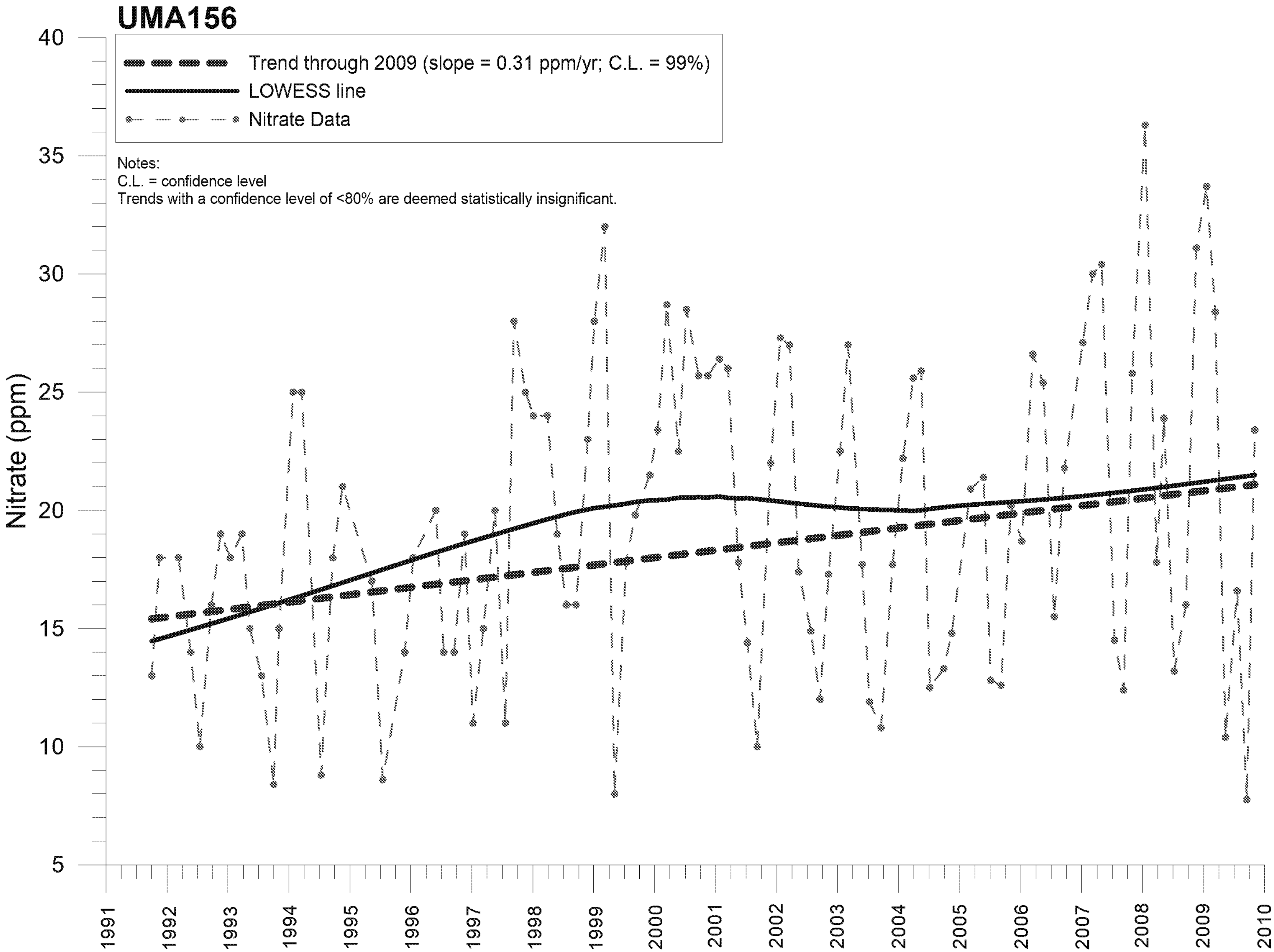

UMA119
Nitrate (ppm)
Trend through 2009 (slope = 0.27 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

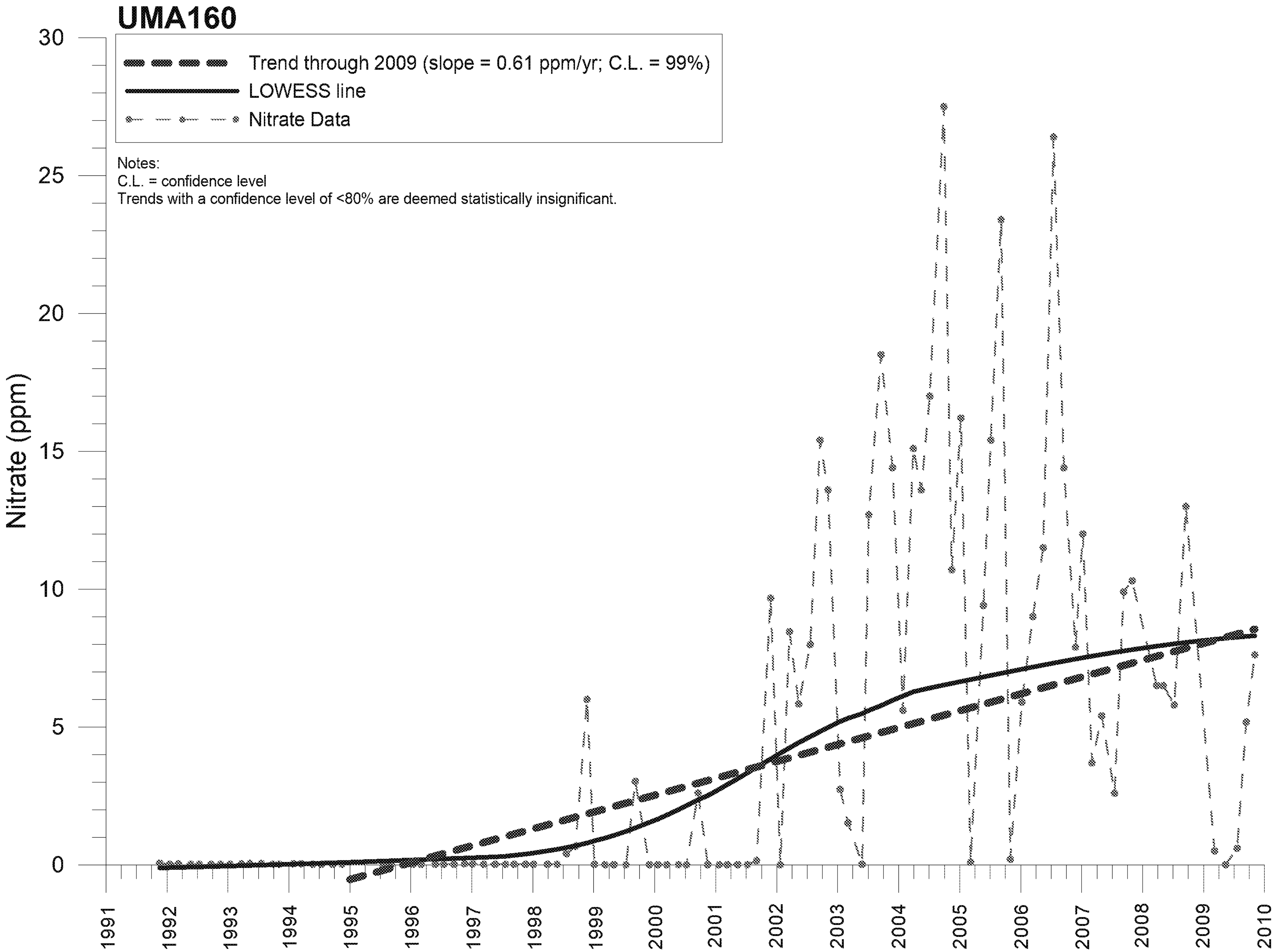


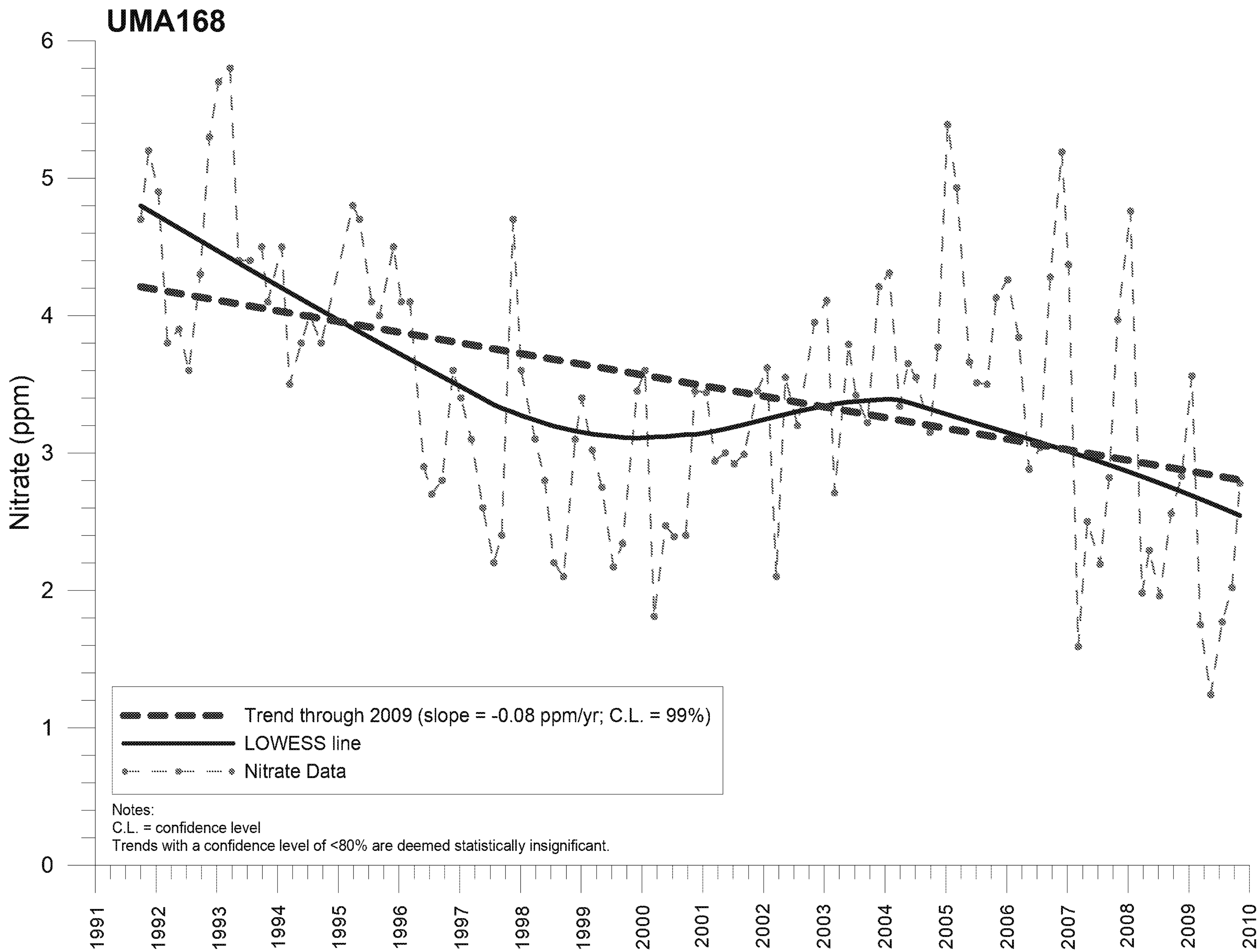
ED_005296_00001040-00094

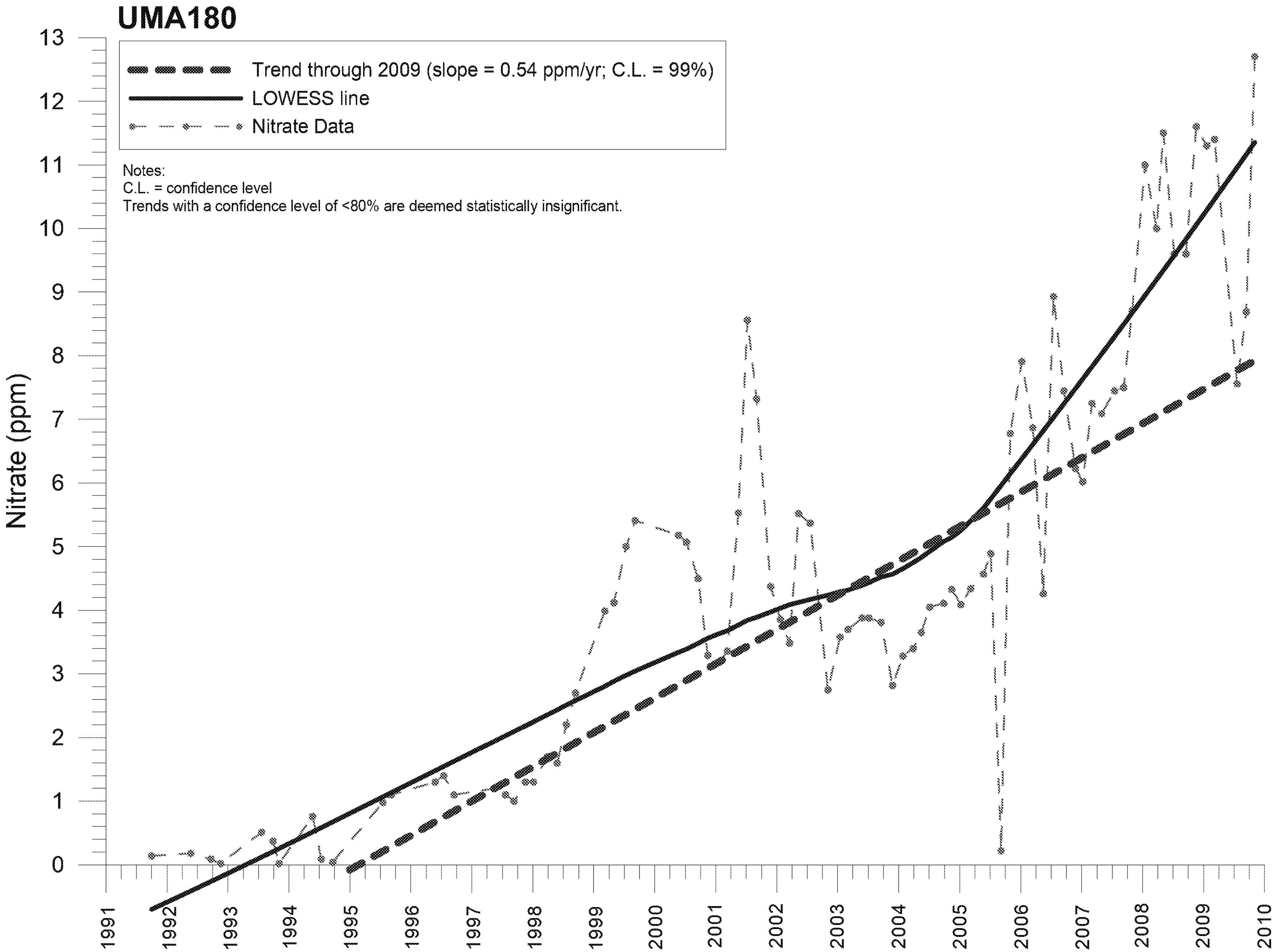

UMA133
Nitrate (ppm)
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.36 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


UMA144
Trend through 2009 (slope = -0.08 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

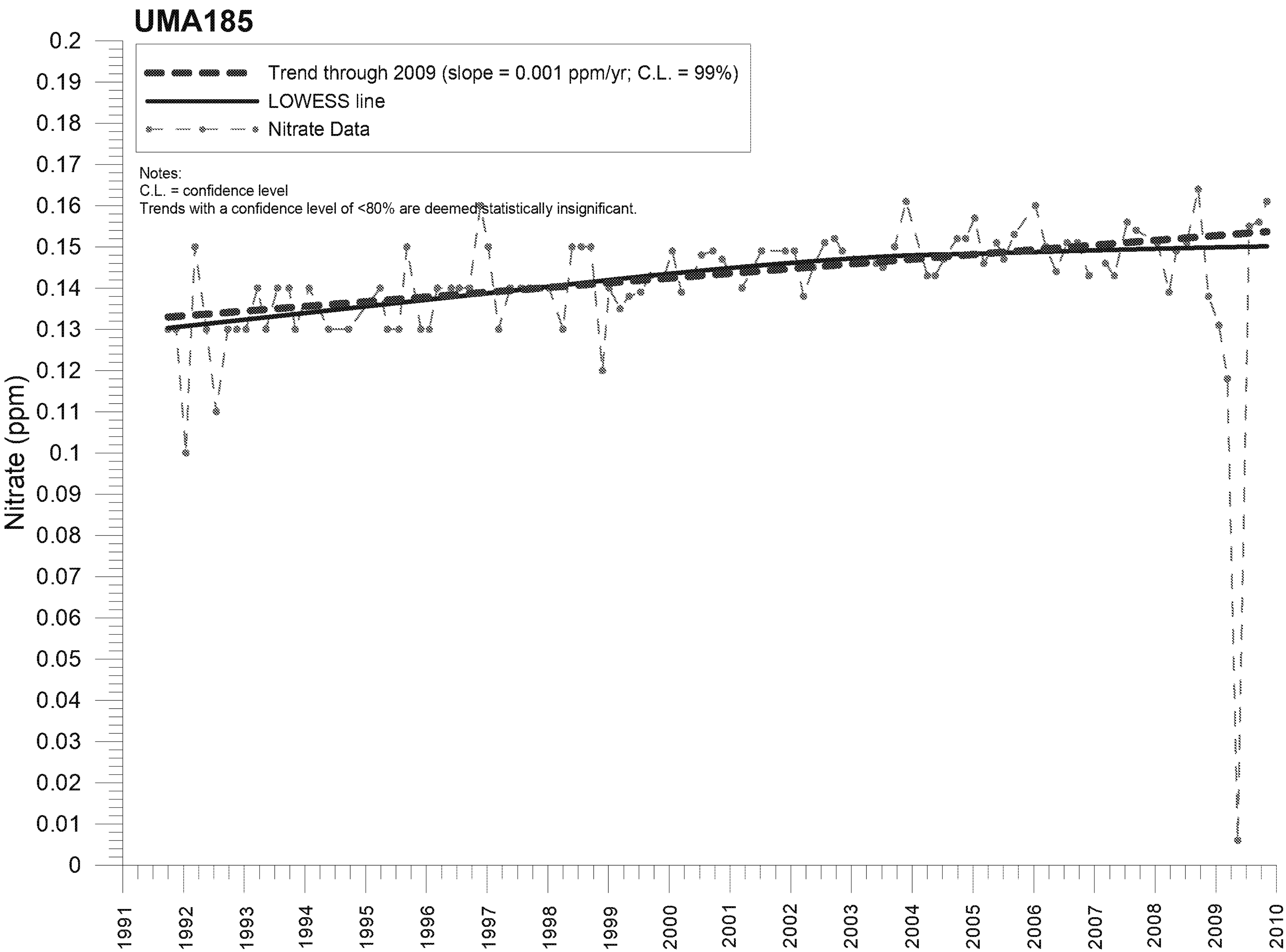

UMA156
Trend through 2009 (slope = 0.31 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
40
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

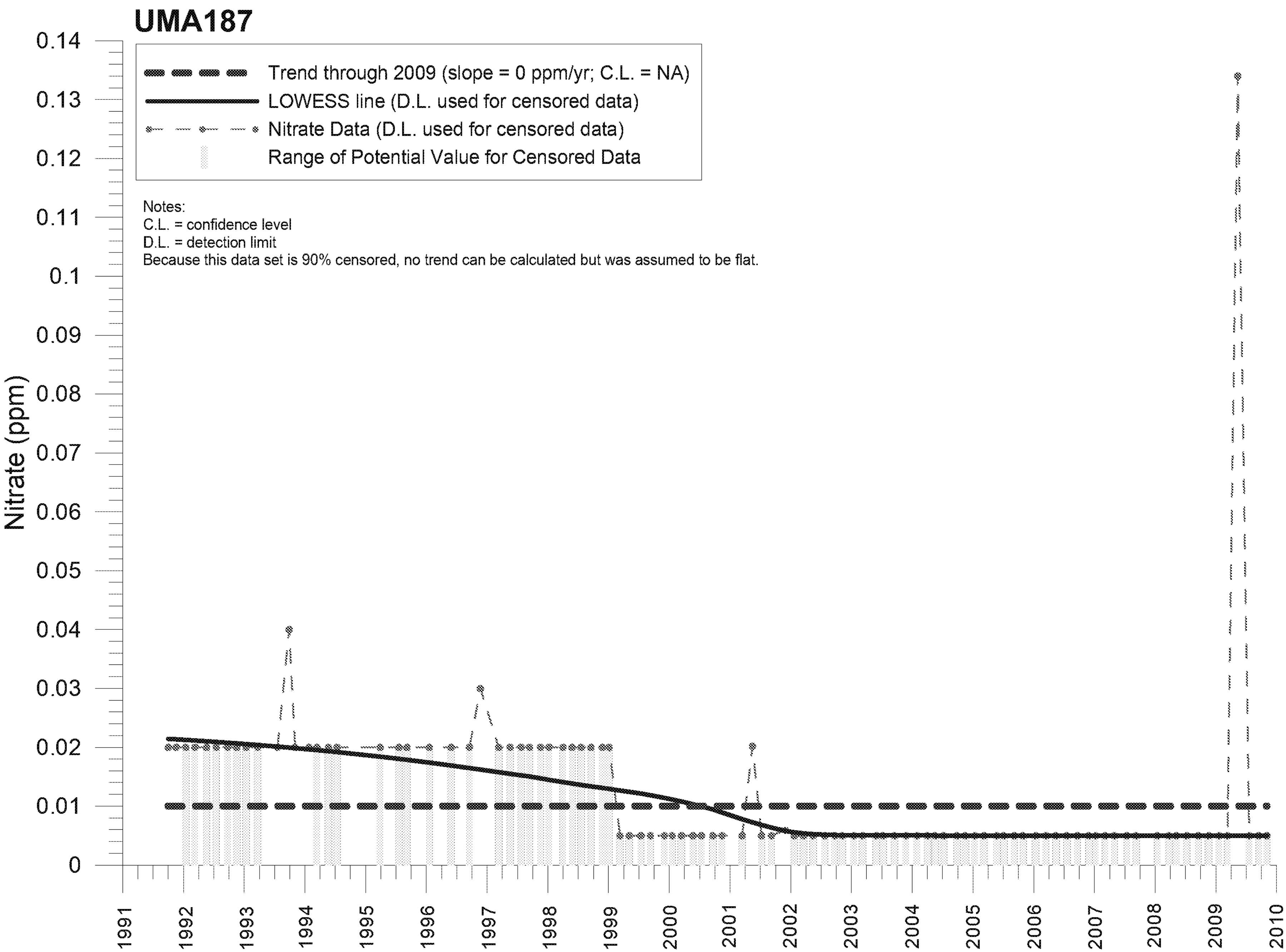

UMA160
Trend through 2009 (slope = 0.61 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
25
30
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


UMA168
Nitrate (ppm)
6
5
4
3
2
1
0
Trend through 2009 (slope = -0.08 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

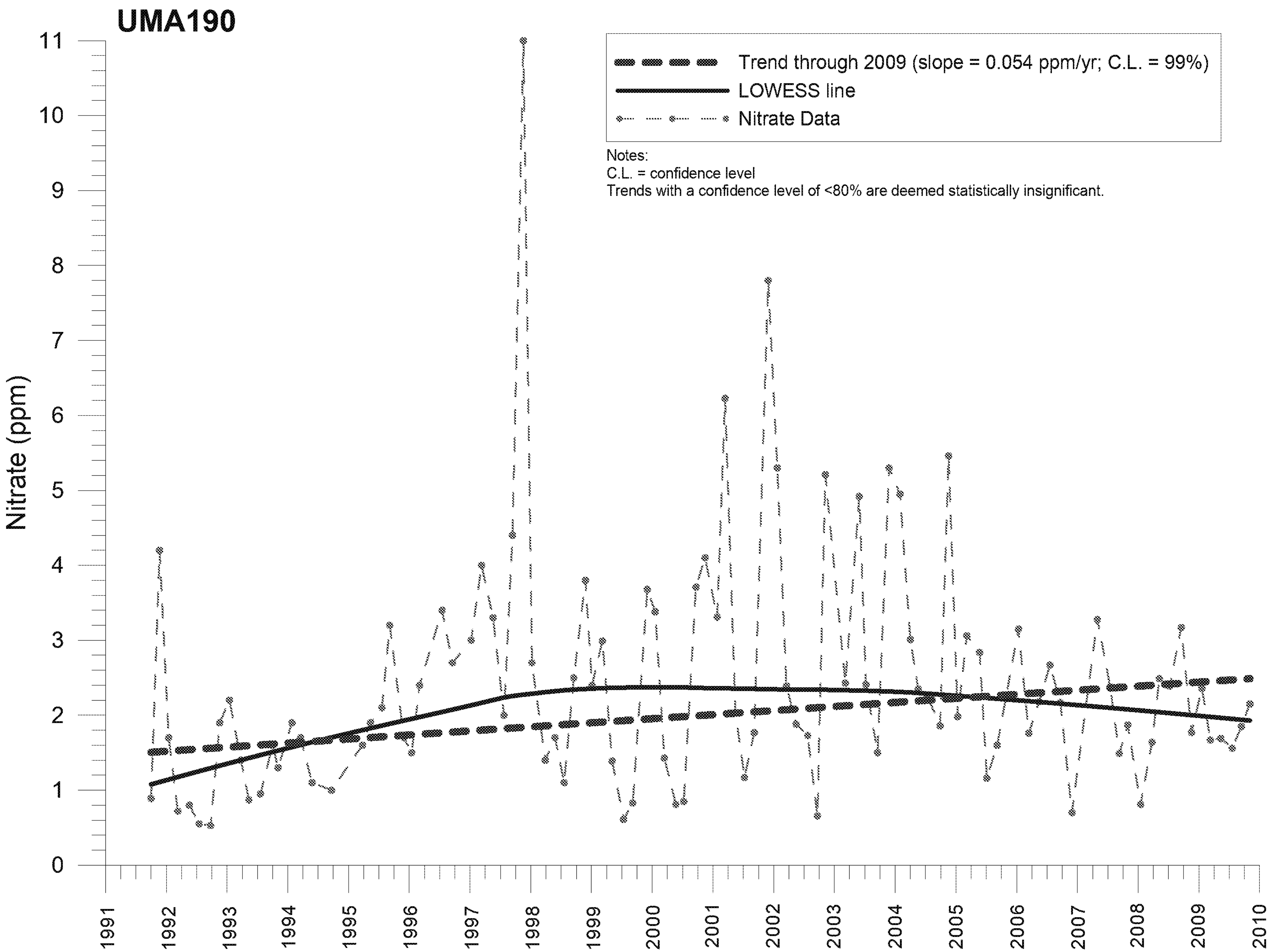


UMA180
Trend through 2009 (slope = 0.54 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

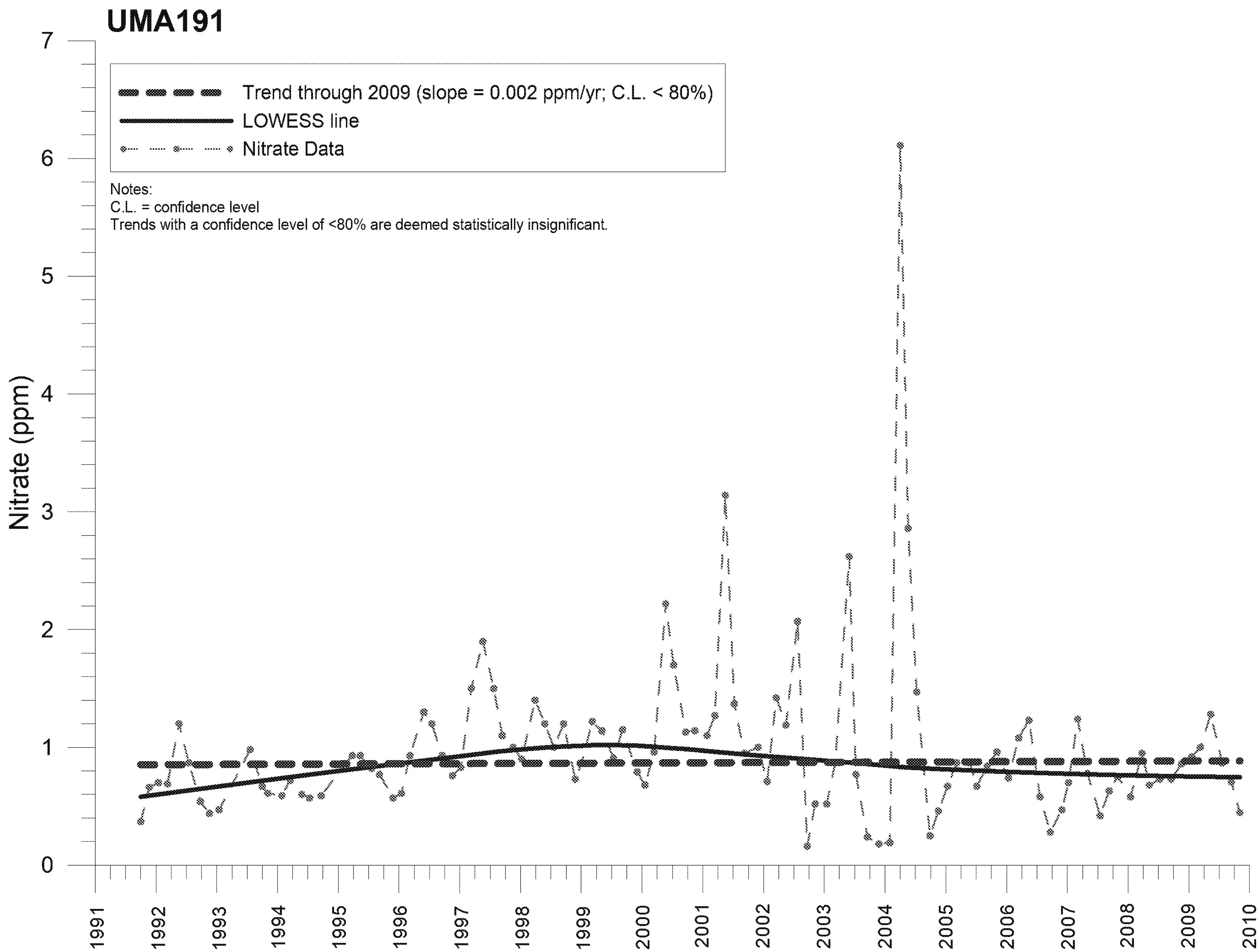

UMA185
Trend through 2009 (slope = 0.001 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

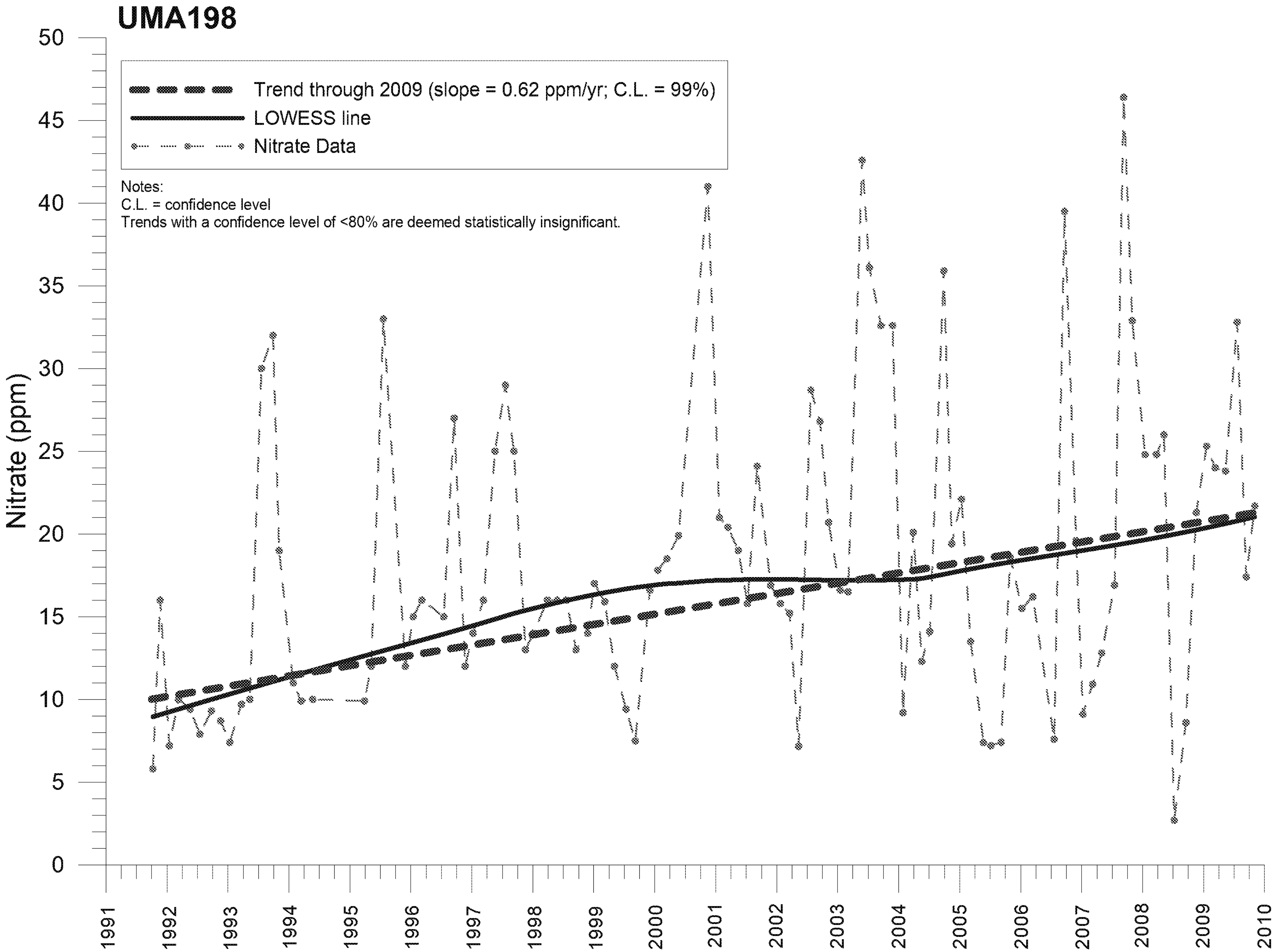


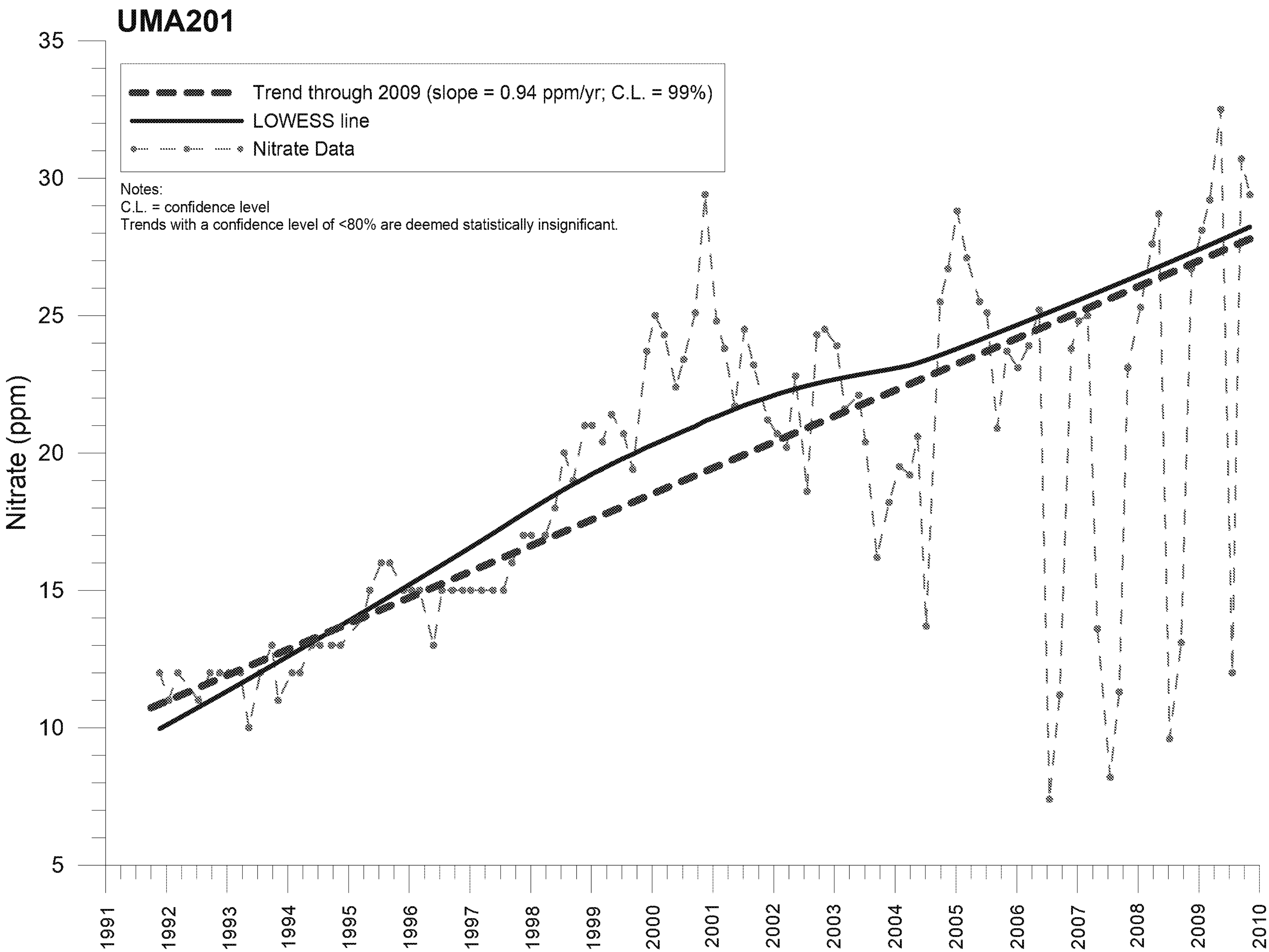
UMA187
Trend through 2009 (slope = 0 ppm/yr; C.L. = NA)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level
D.L. = detection limit
Because this data set is 90% censored, no trend can be calculated but was assumed to be flat.
Nitrate (ppm)
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

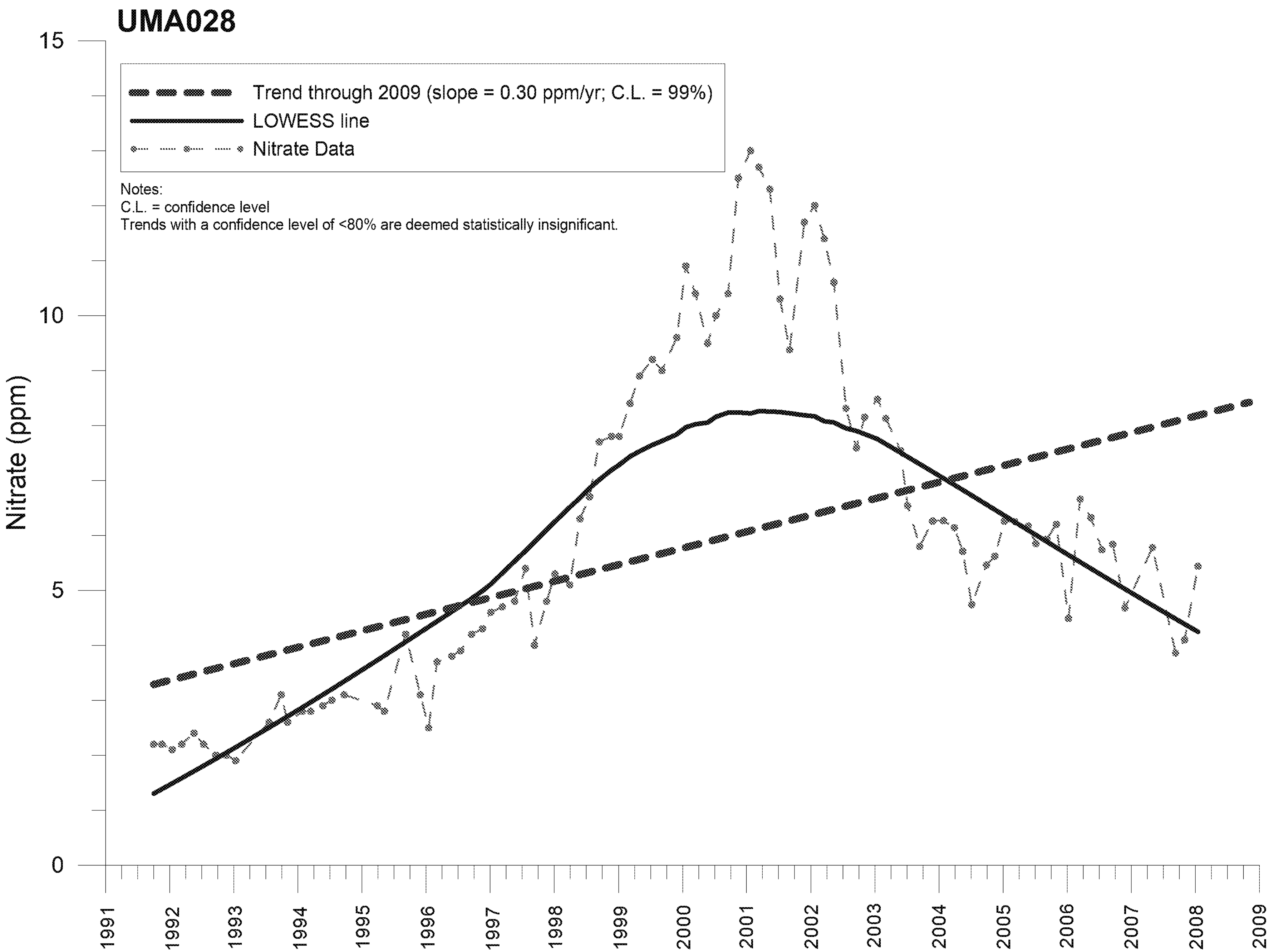


ED_005296_00001040-00103

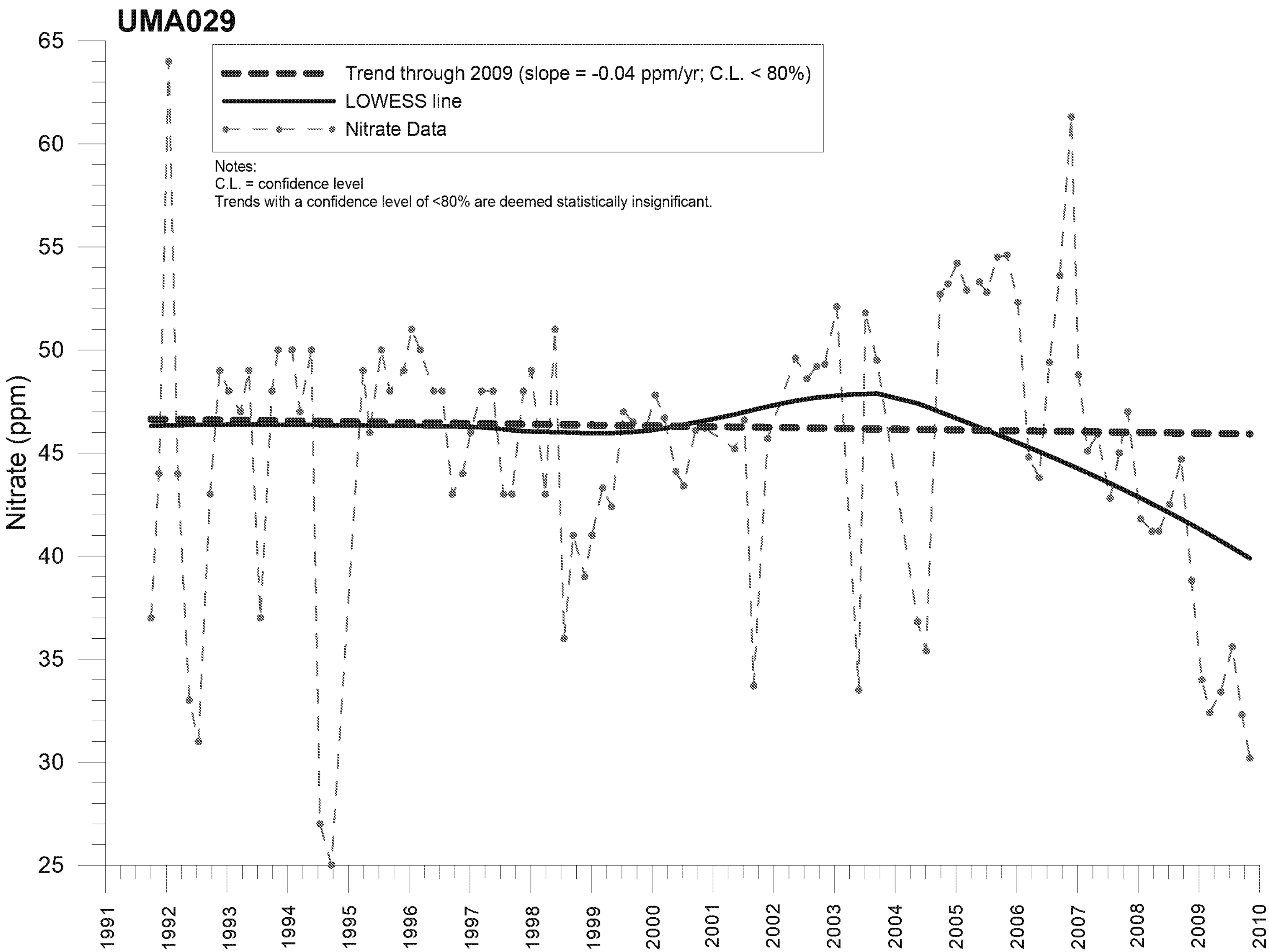

UMA191
Trend through 2009 (slope = 0.002 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
7
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


UMA198
Trend through 2009 (slope = 0.62 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

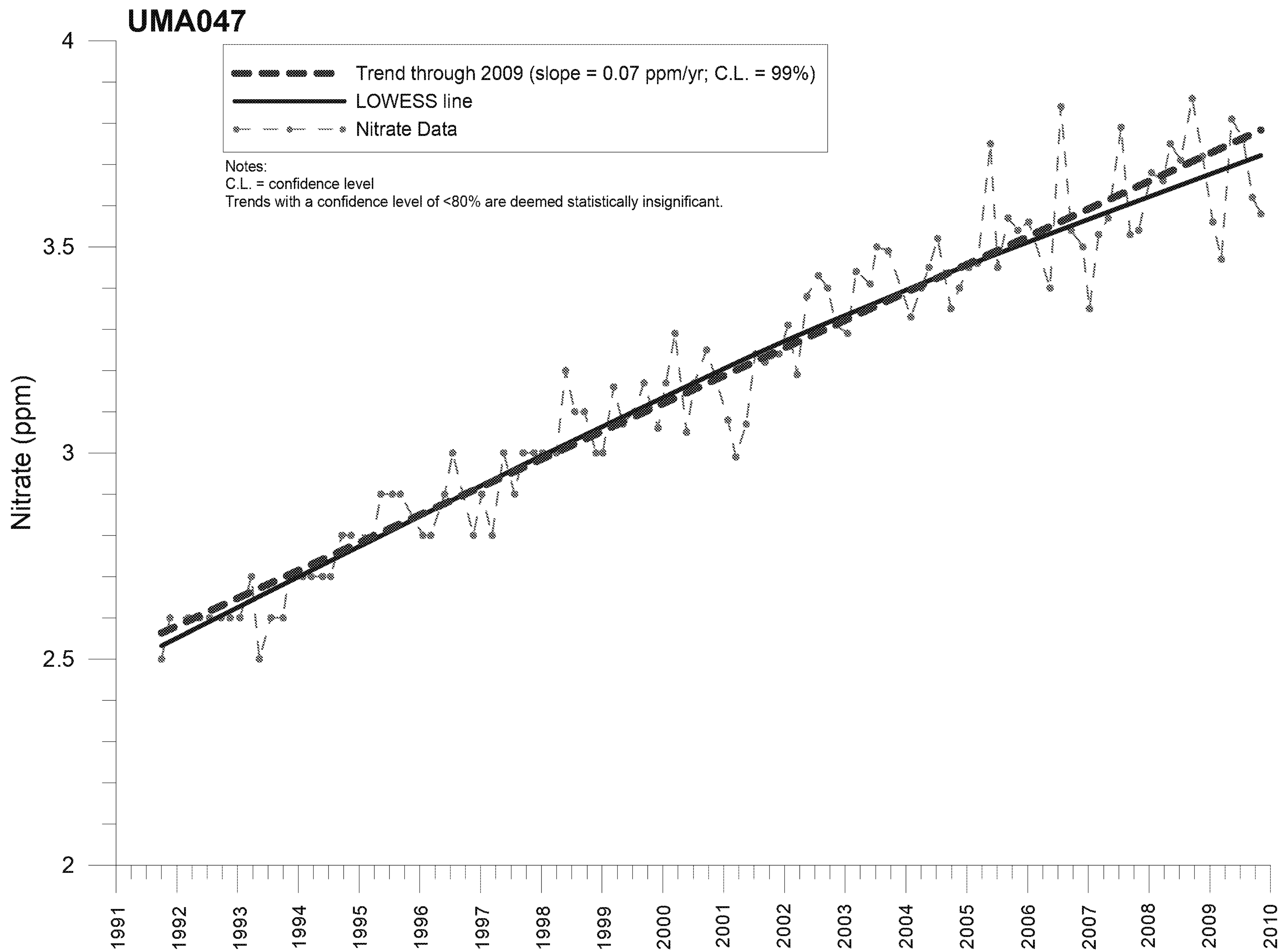

UMA201
Trend through 2009 (slope = 0.94 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



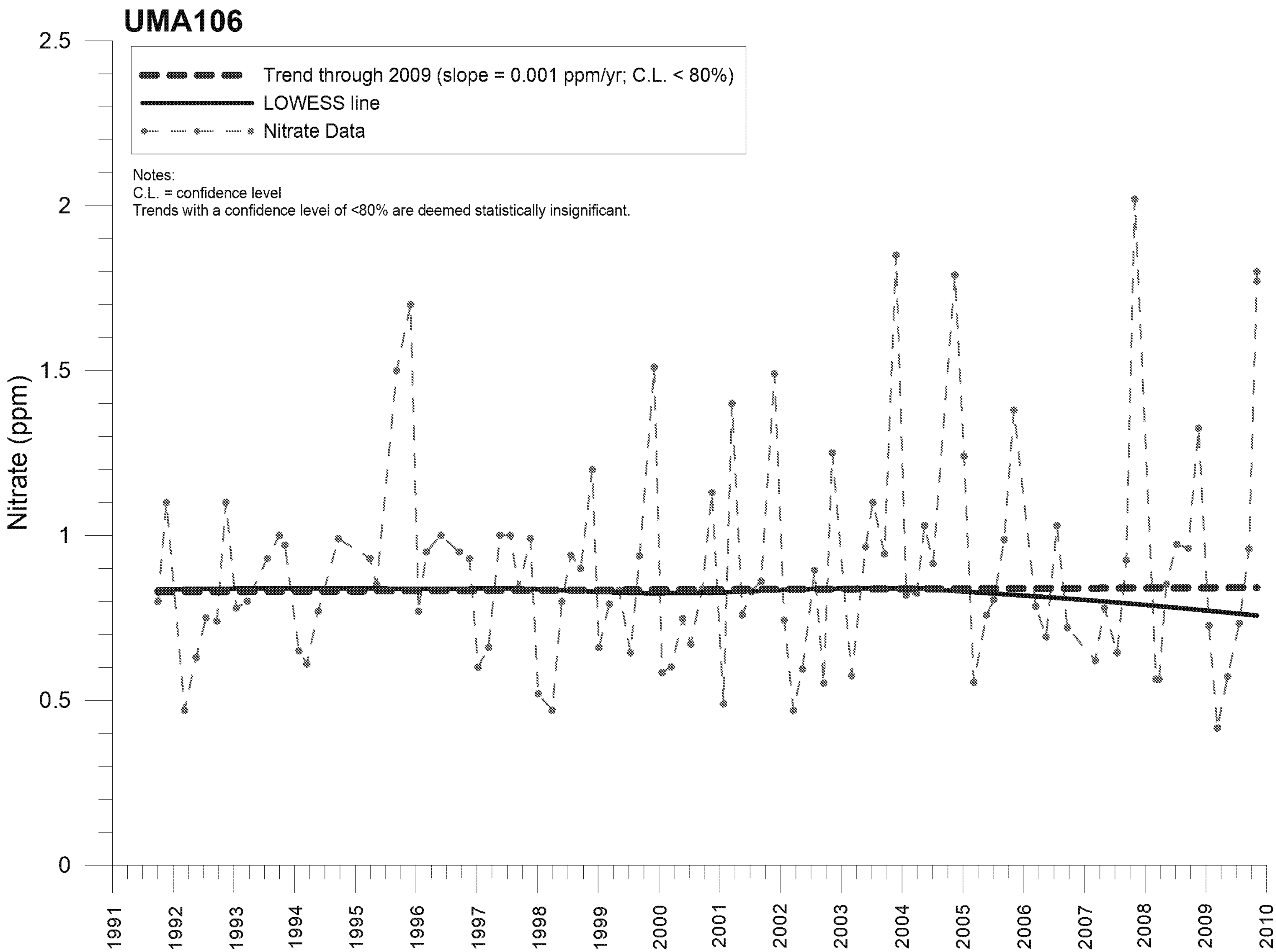
ED_005296_00001040-00107

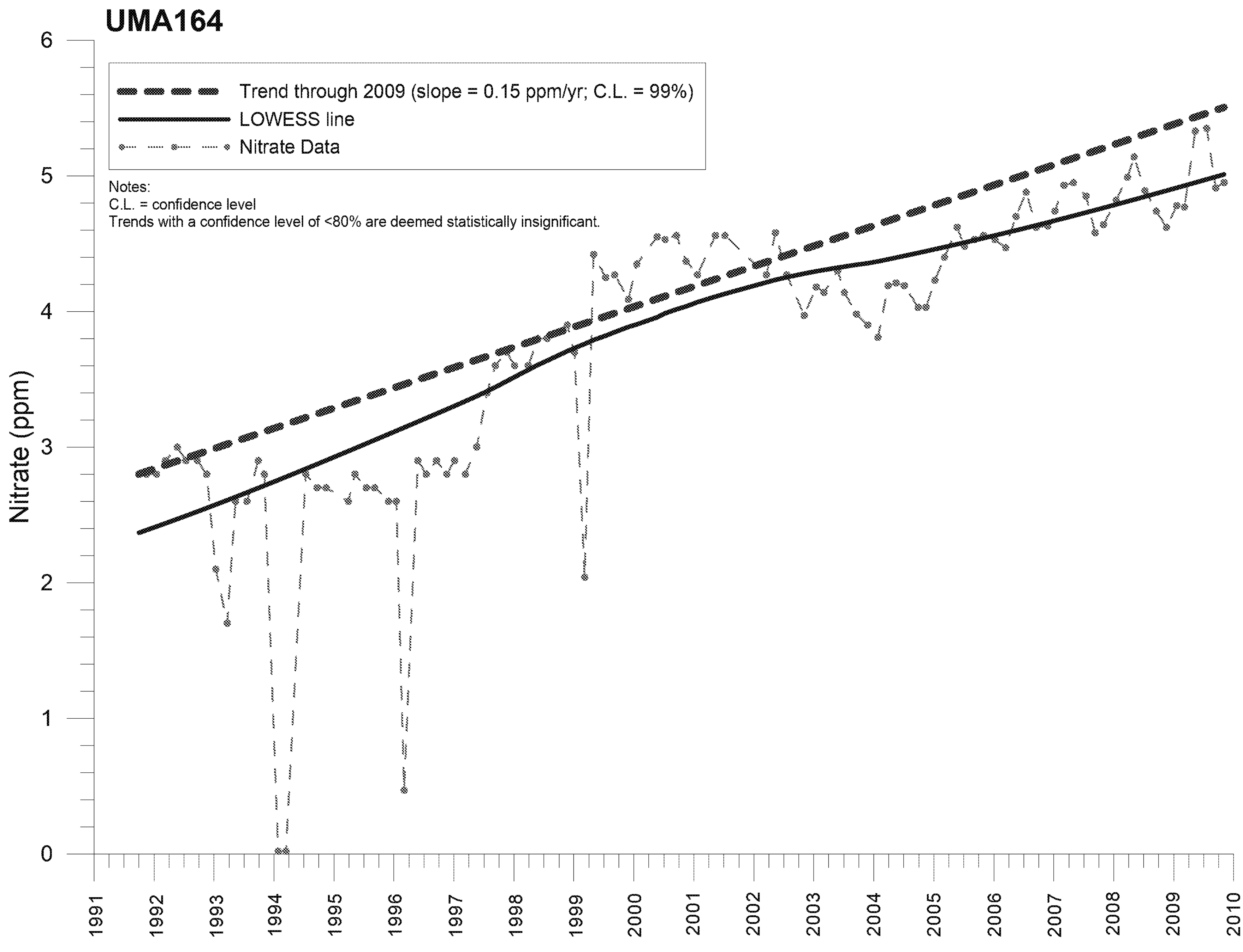


ED_005296_00001040-00108



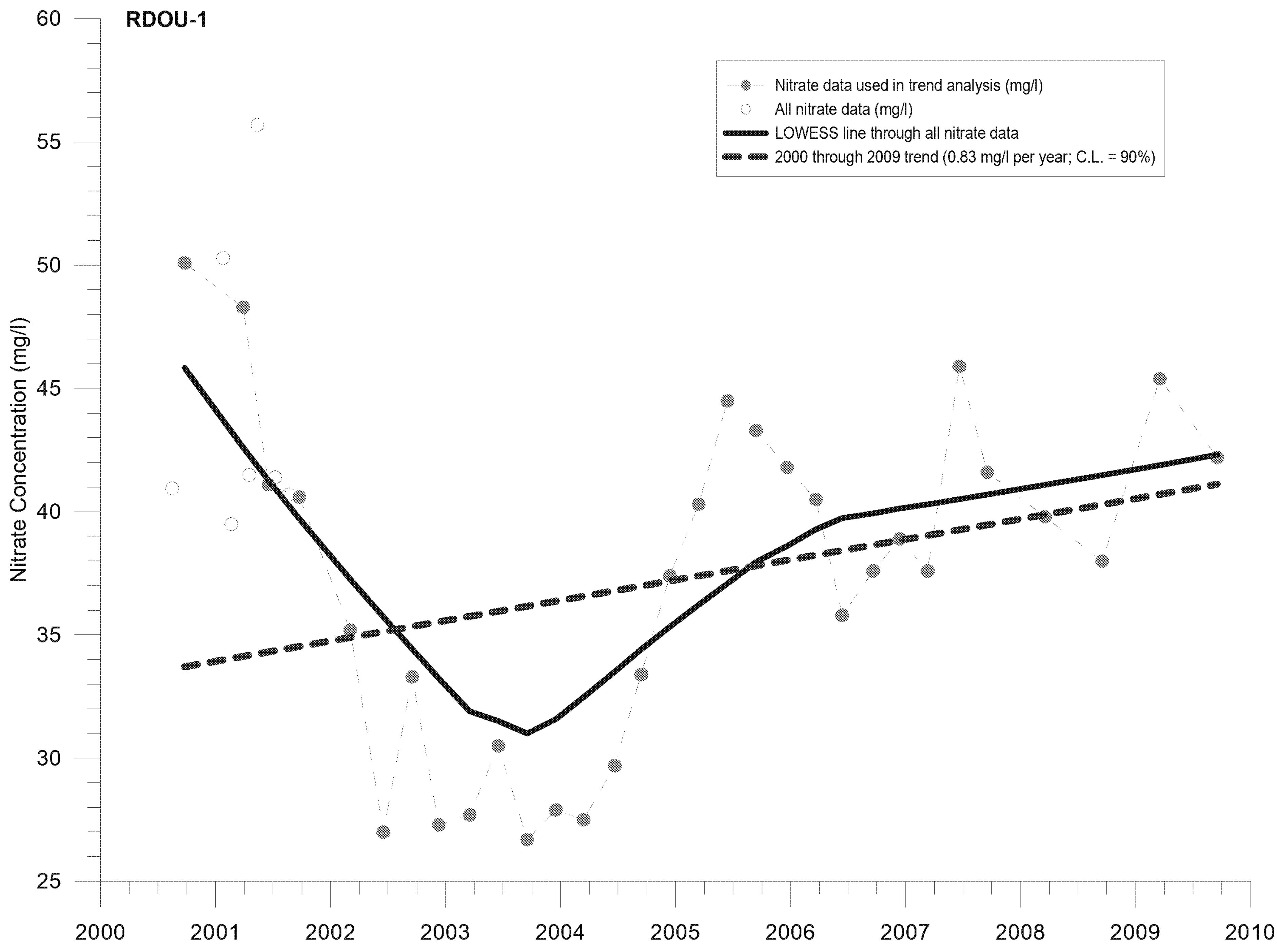
UMA047
Trend through 2009 (slope = 0.07 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
4
3.5
3
2.5
2
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

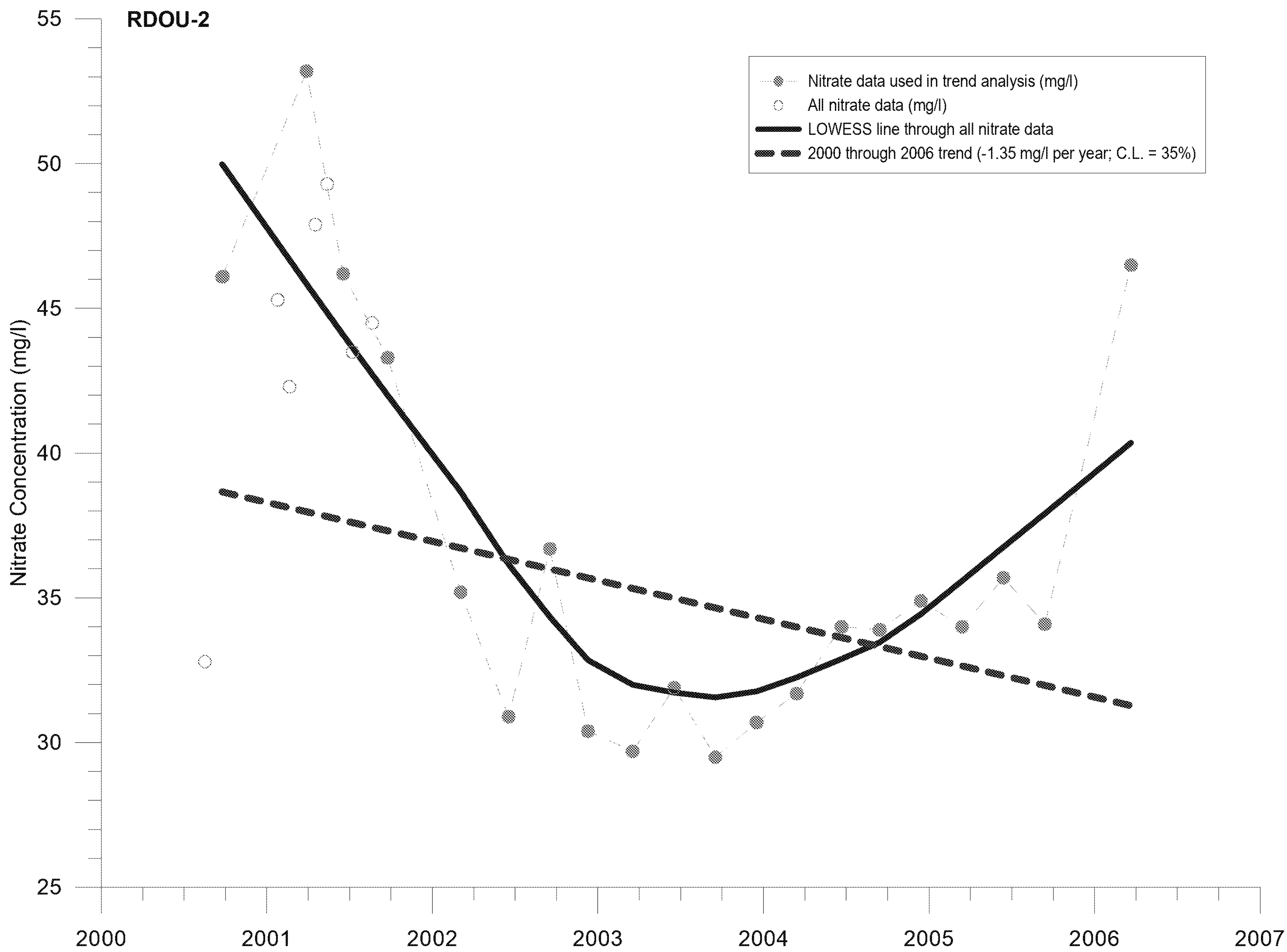

UMA106
Trend through 2009 (slope = 0.001 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
2.5
2
1.5
1
0.5
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

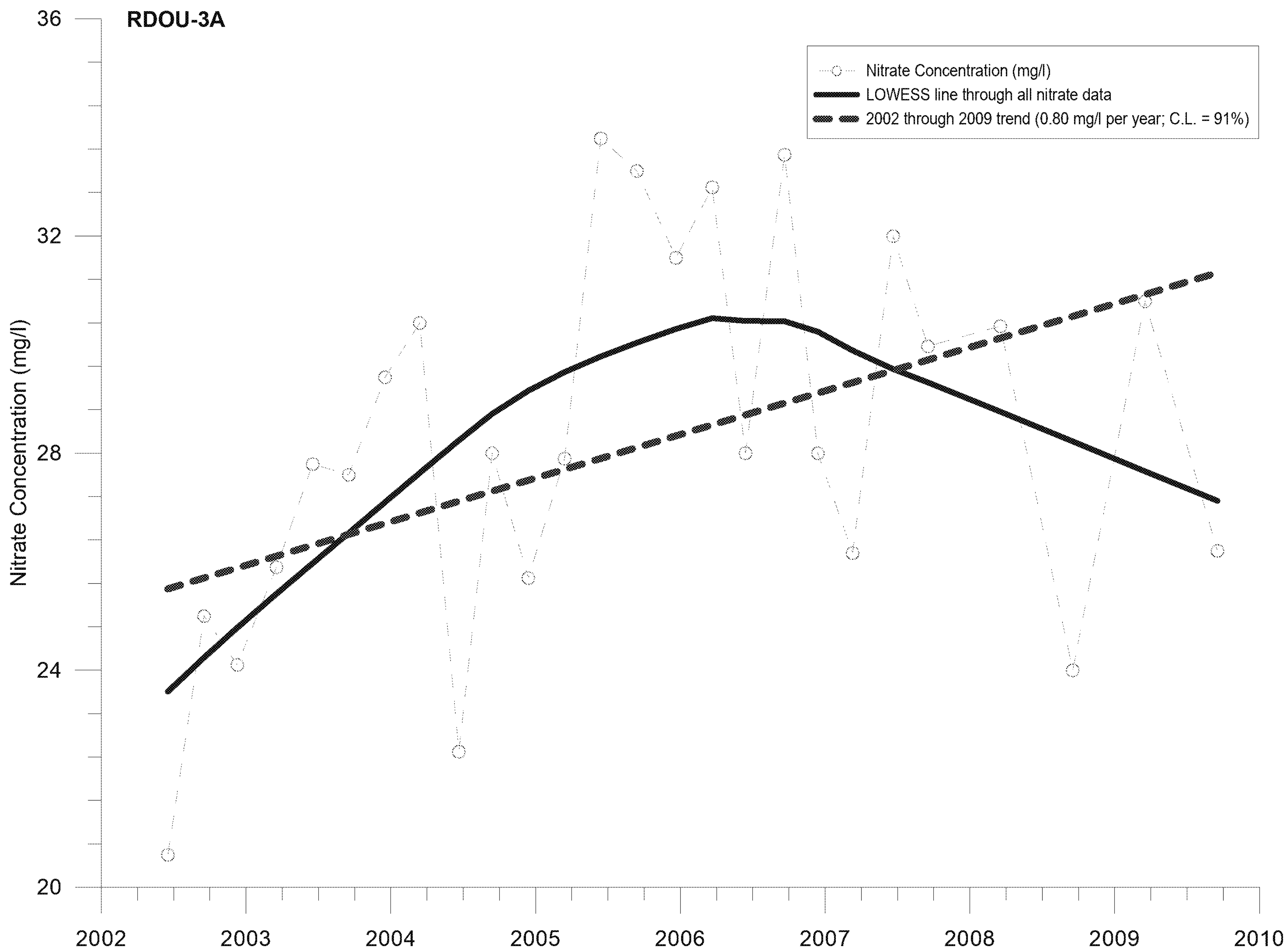

UMA164
Trend through 2009 (slope = 0.15 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Appendix B

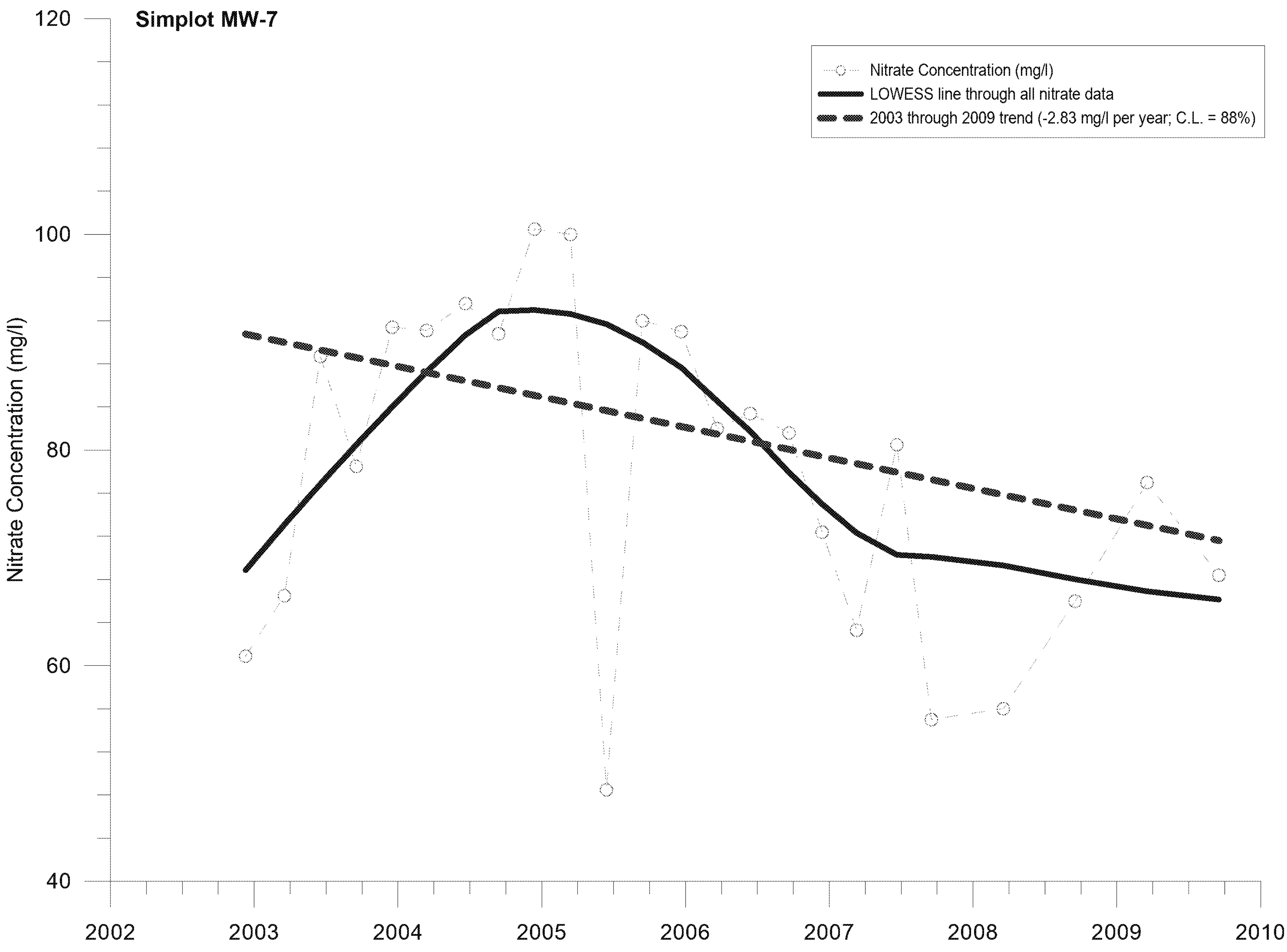
Time Series Plots for Three Mile Canyon Farm Wells


RDOU-1
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2000 through 2009 trend (0.83 mg/l per year; C.L. = 90%)
Nitrate Concentration (mg/l)
60
55
50
45
40
35
30
25
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

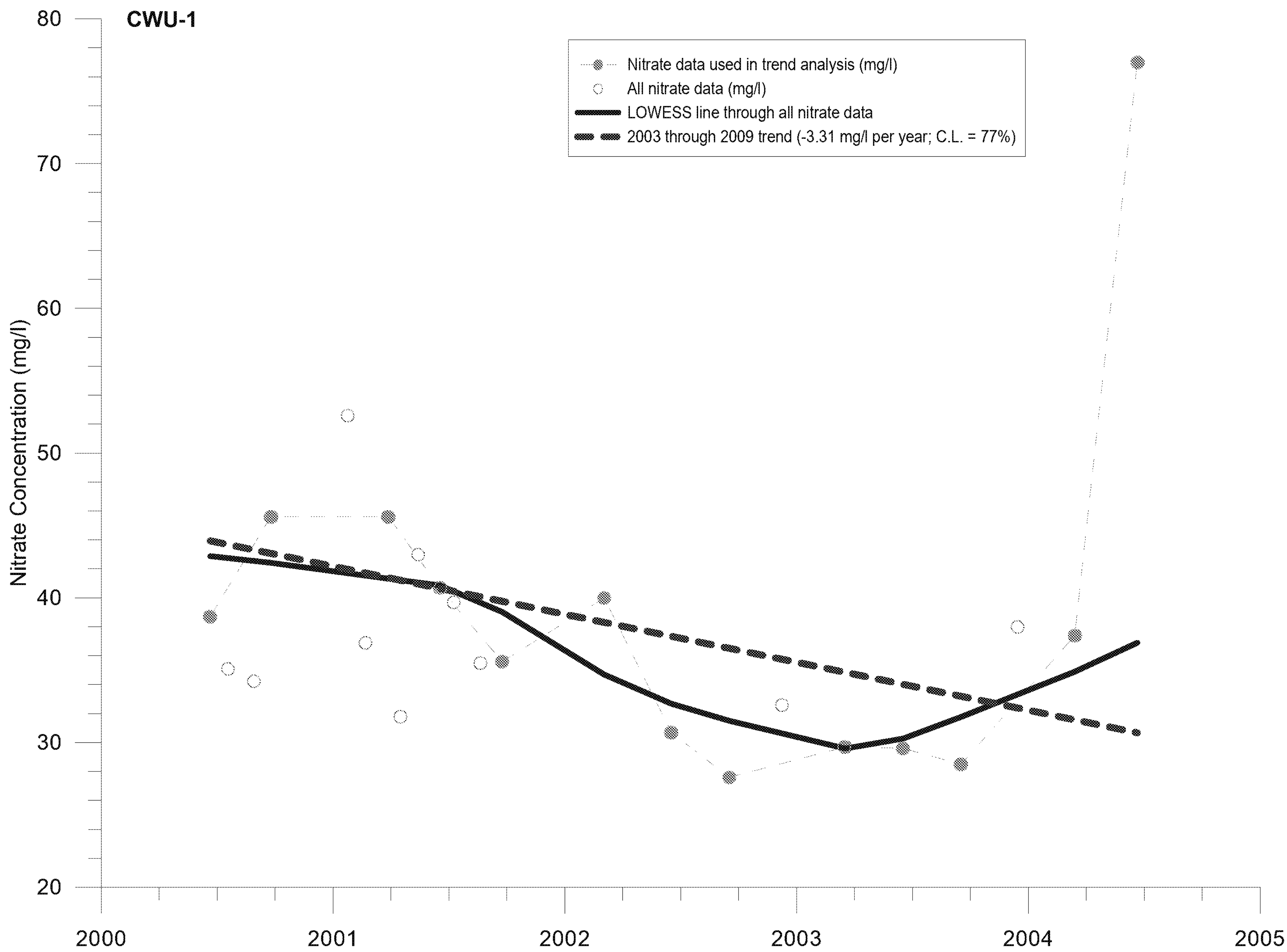

RDOU-2
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2000 through 2006 trend (-1.35 mg/l per year; C.L. = 35%)
Nitrate Concentration (mg/l)
55
50
45
40
35
30
25
2000
2001
2002
2003
2004
2005
2006
2007

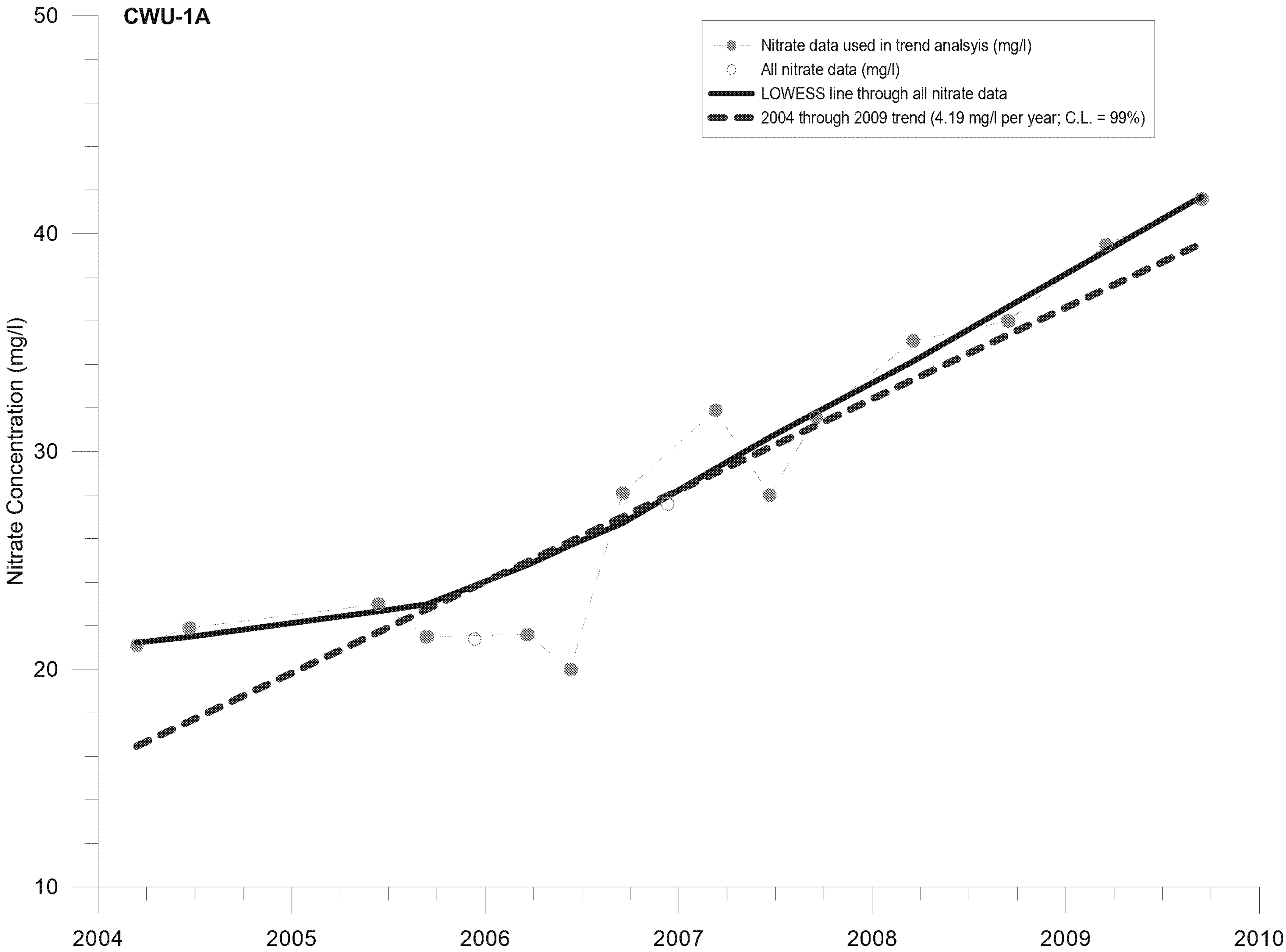


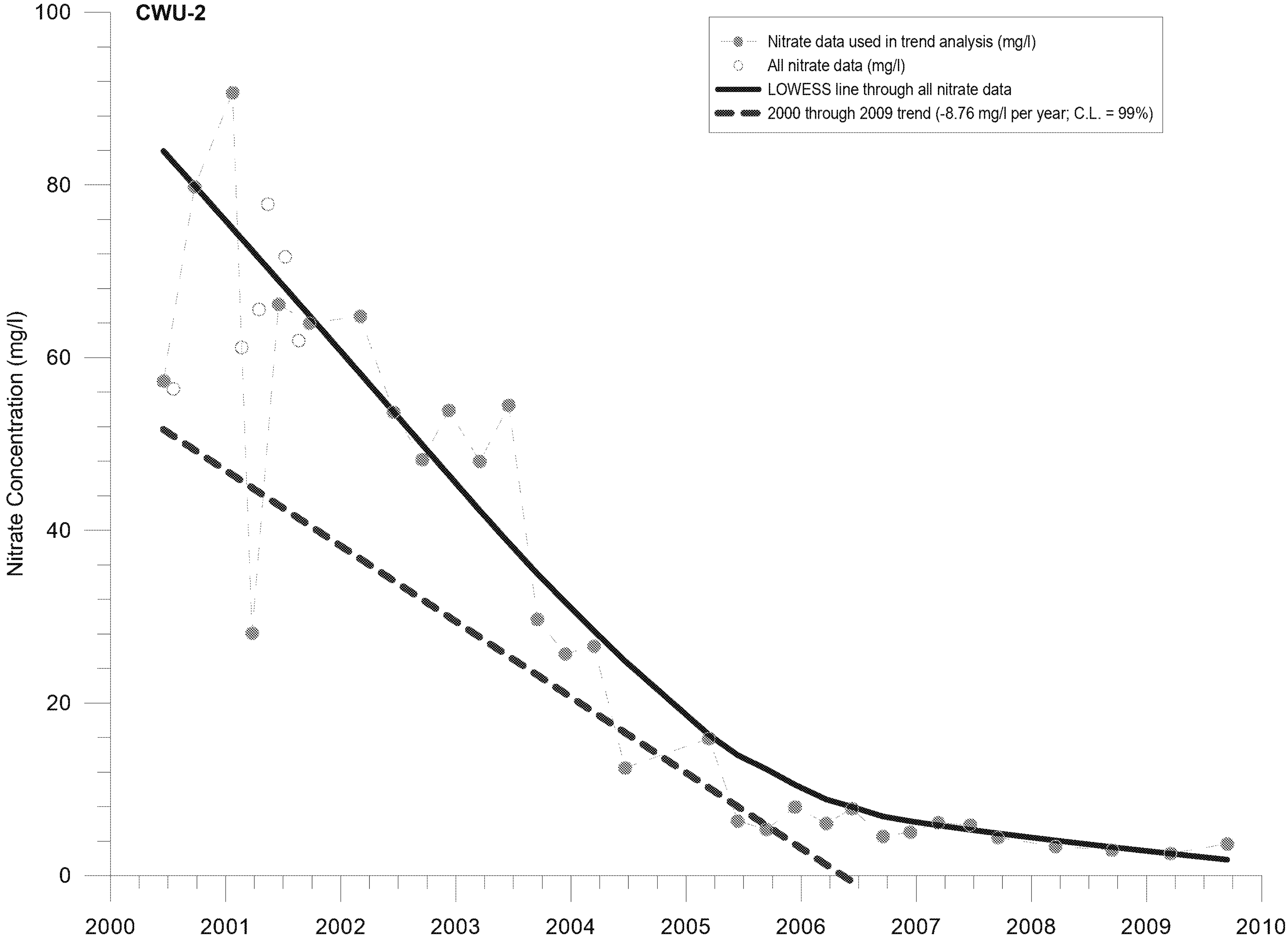
ED_005296_00001040-00115

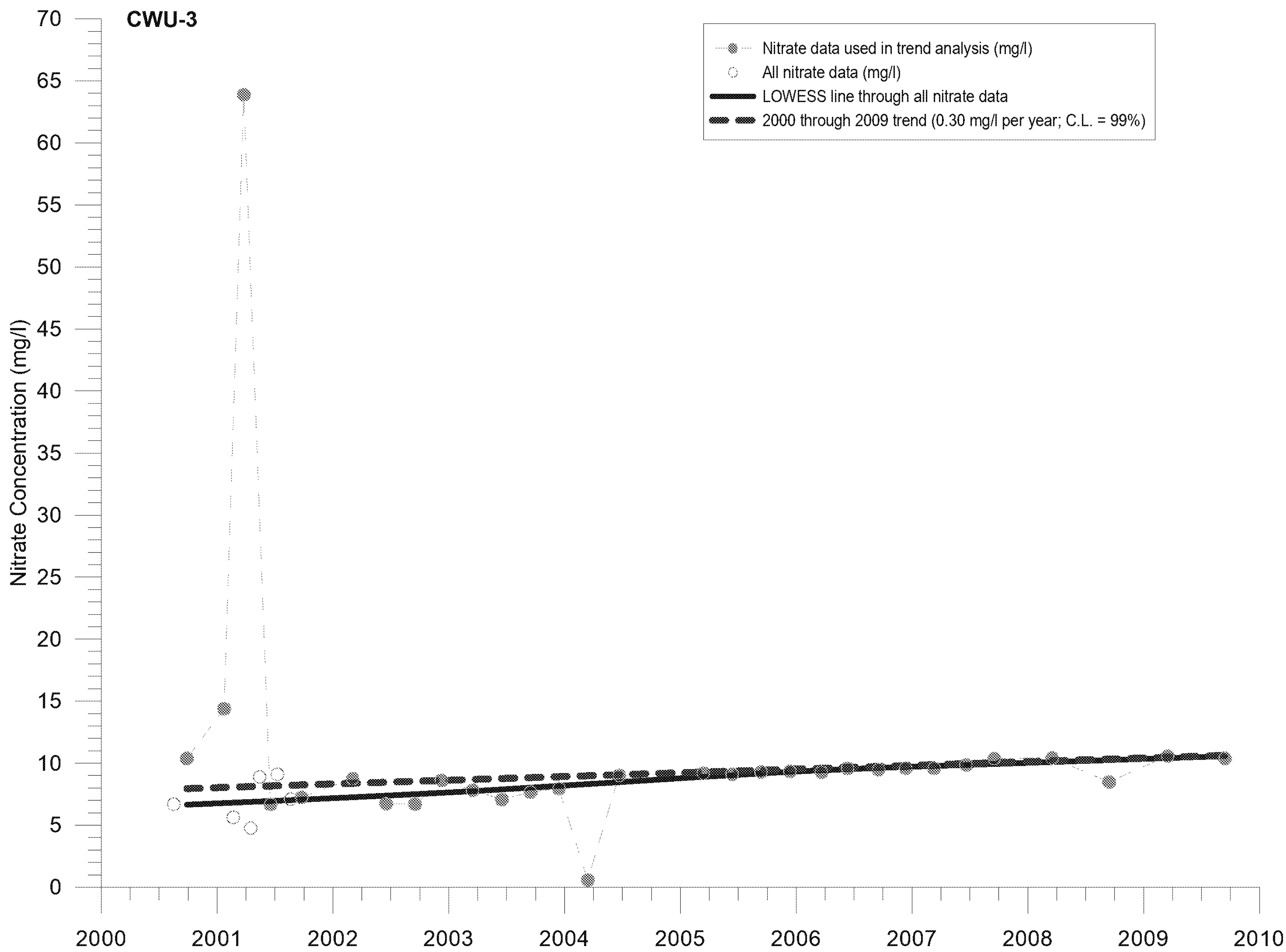


Simplot MW-7
Nitrate Concentration (mg/l)
LOWESS line through all nitrate data
2003 through 2009 trend (-2.83 mg/l per year; C.L. = 88%)
Nitrate Concentration (mg/l)
120
100
80
60
40
2002
2003
2004
2005
2006
2007
2008
2009
2010

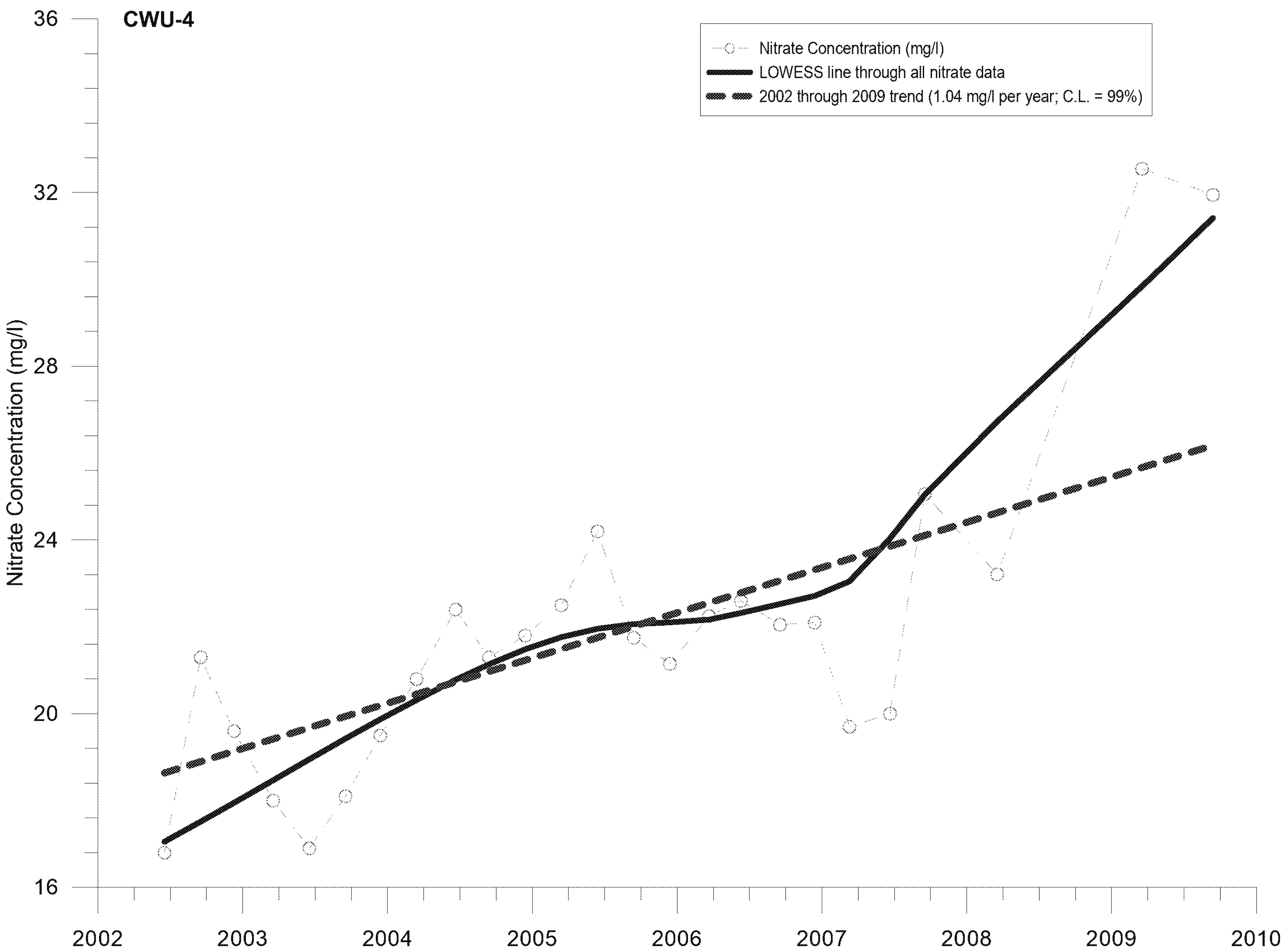

CWU-1
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2003 through 2009 trend (-3.31 mg/l per year; C.L. = 77%)
Nitrate Concentration (mg/l)
80
70
60
50
40
30
20
2000
2001
2002
2003
2004
2005


CWU-1A
Nitrate data used in trend analsyis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2004 through 2009 trend (4.19 mg/l per year; C.L. = 99%)
Nitrate Concentration (mg/l)
50
40
30
20
10
2004
2005
2006
2007
2008
2009
2010

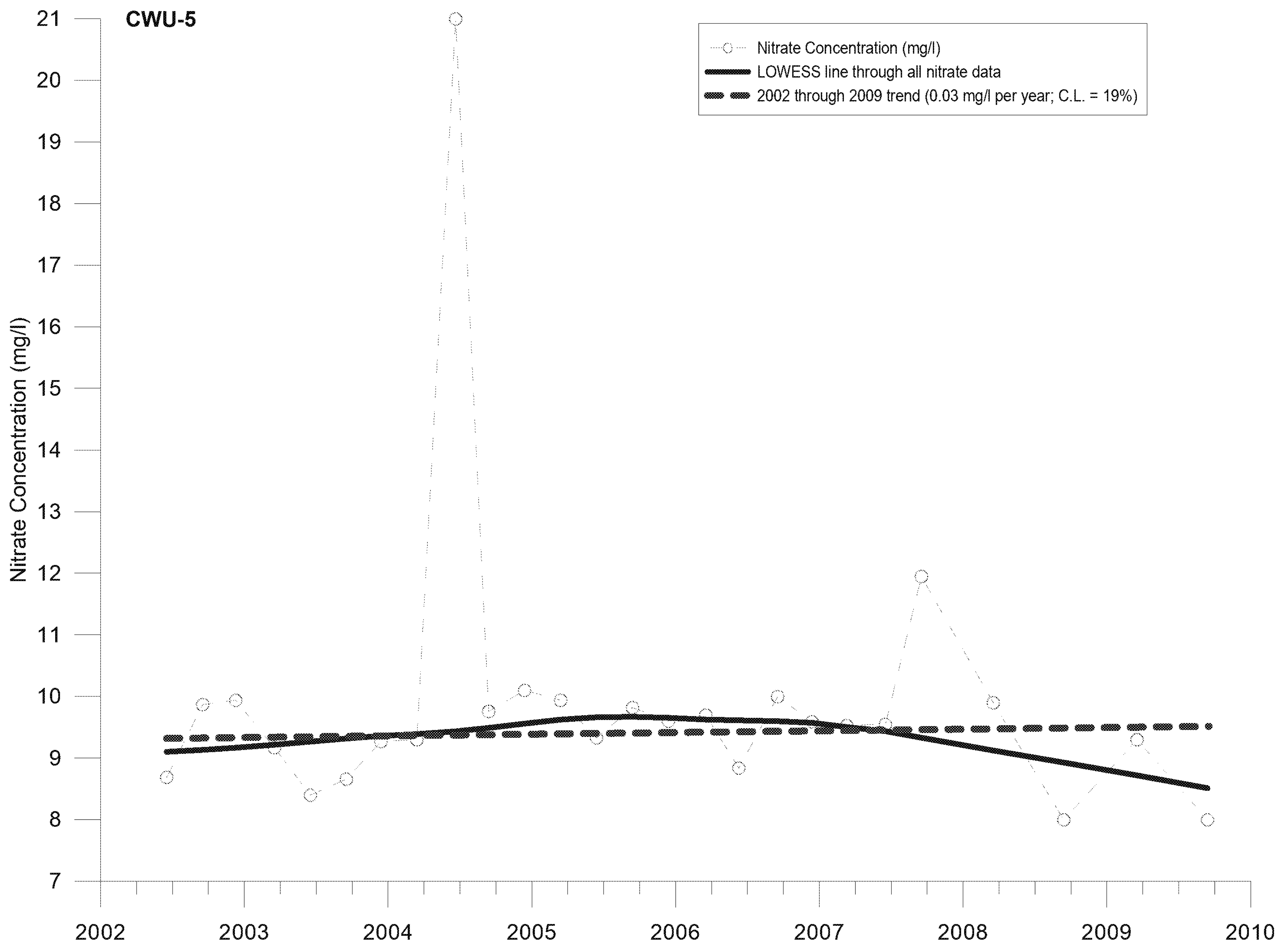

CWU-2
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2000 through 2009 trend (-8.76 mg/l per year; C.L. = 99%)
Nitrate Concentration (mg/l)
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

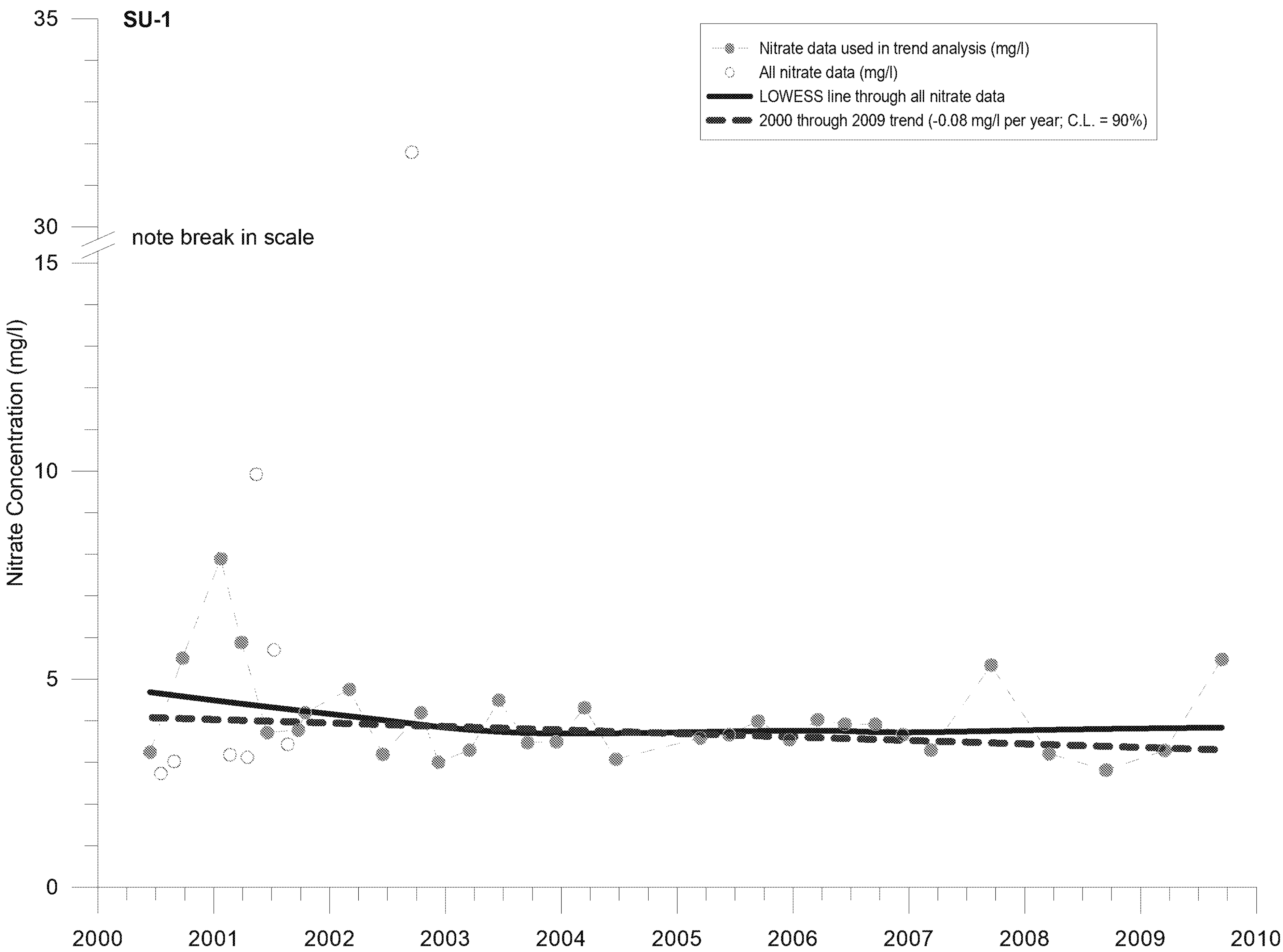


ED_005296_00001040-00120

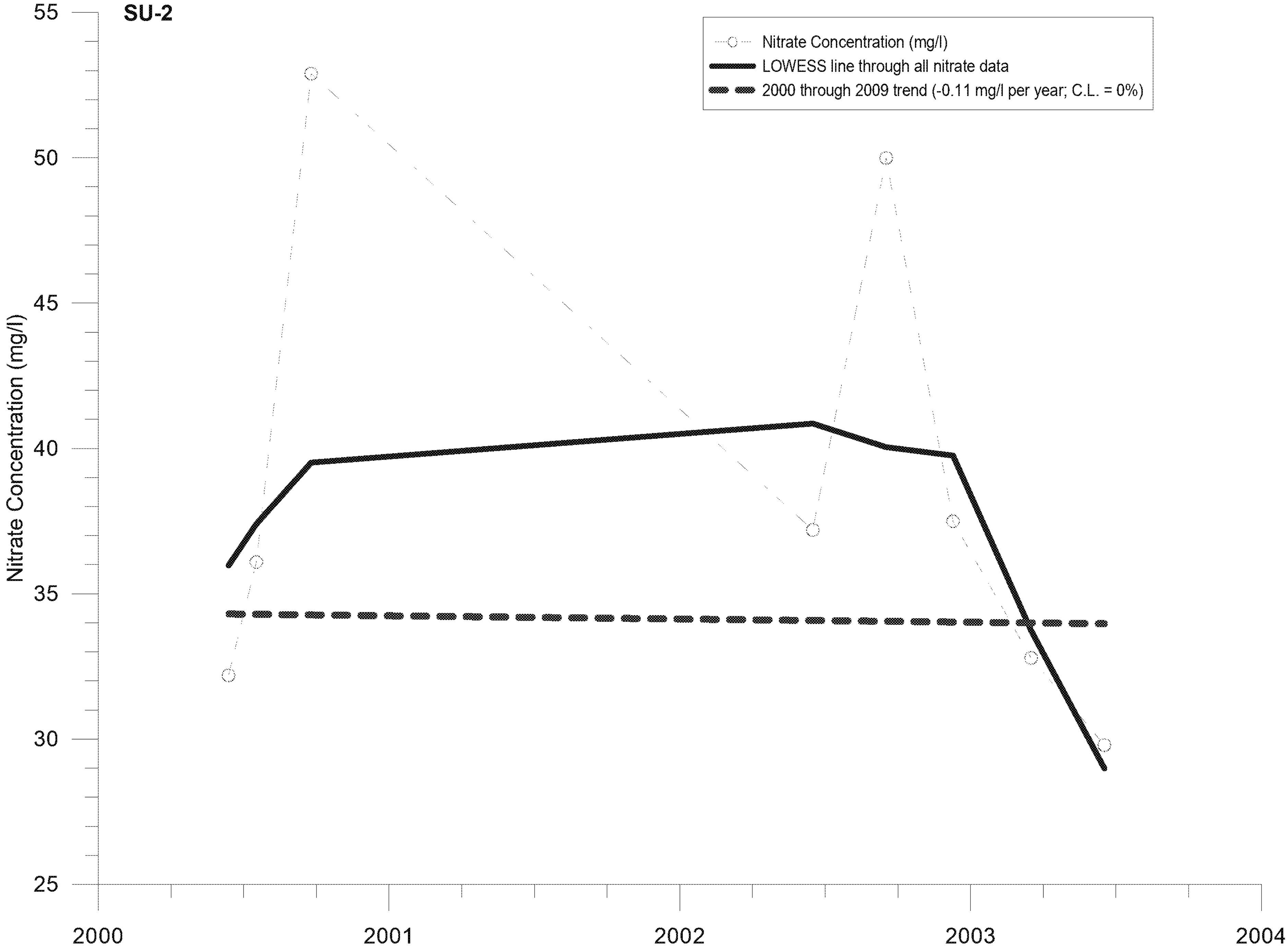


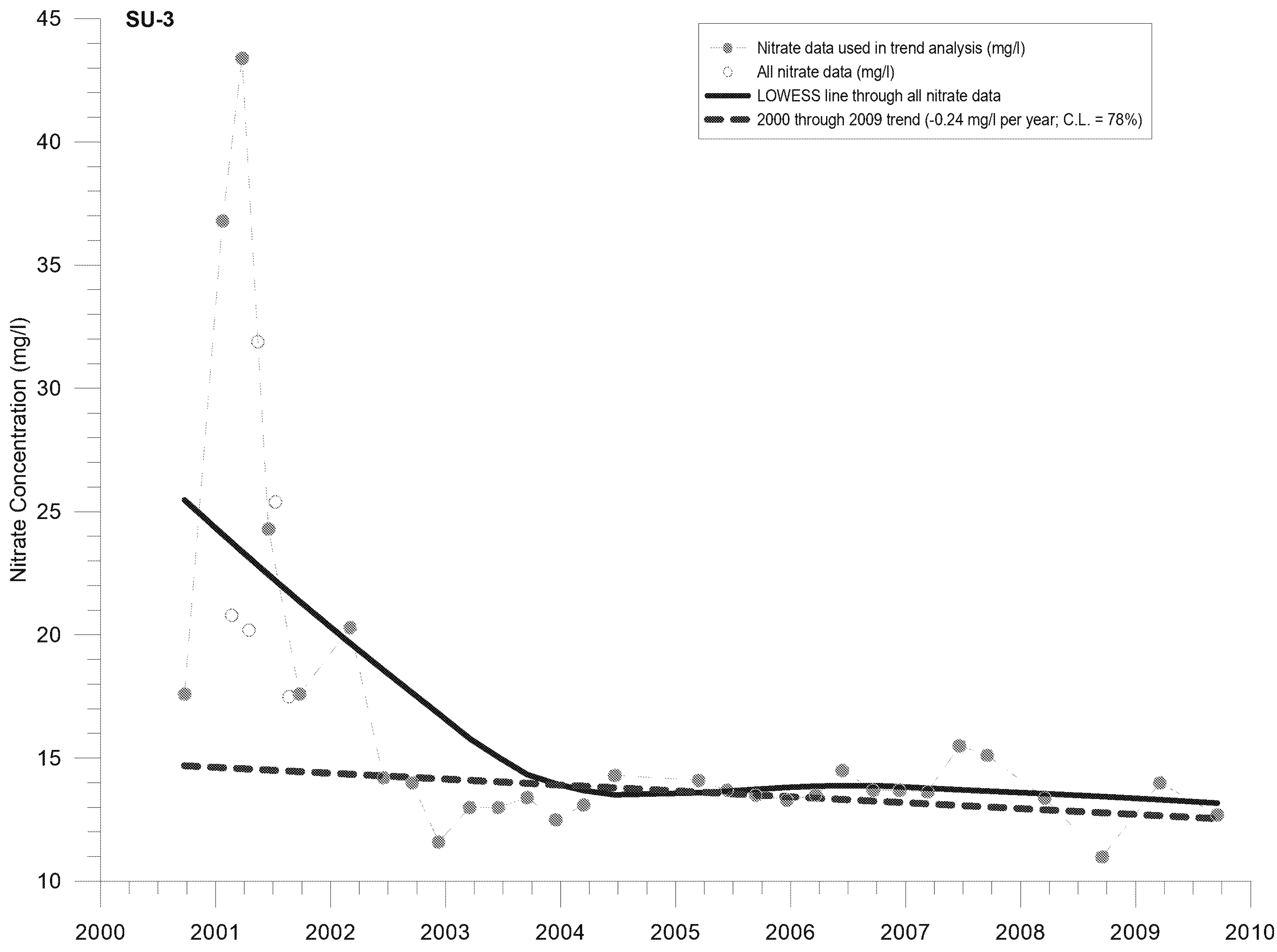
ED_005296_00001040-00121


CWU-5
Nitrate Concentration (mg/l)
LOWESS line through all nitrate data
2002 through 2009 trend (0.03 mg/l per year; C.L. = 19%)
Nitrate Concentration (mg/l)
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
2002
2003
2004
2005
2006
2007
2008
2009
2010

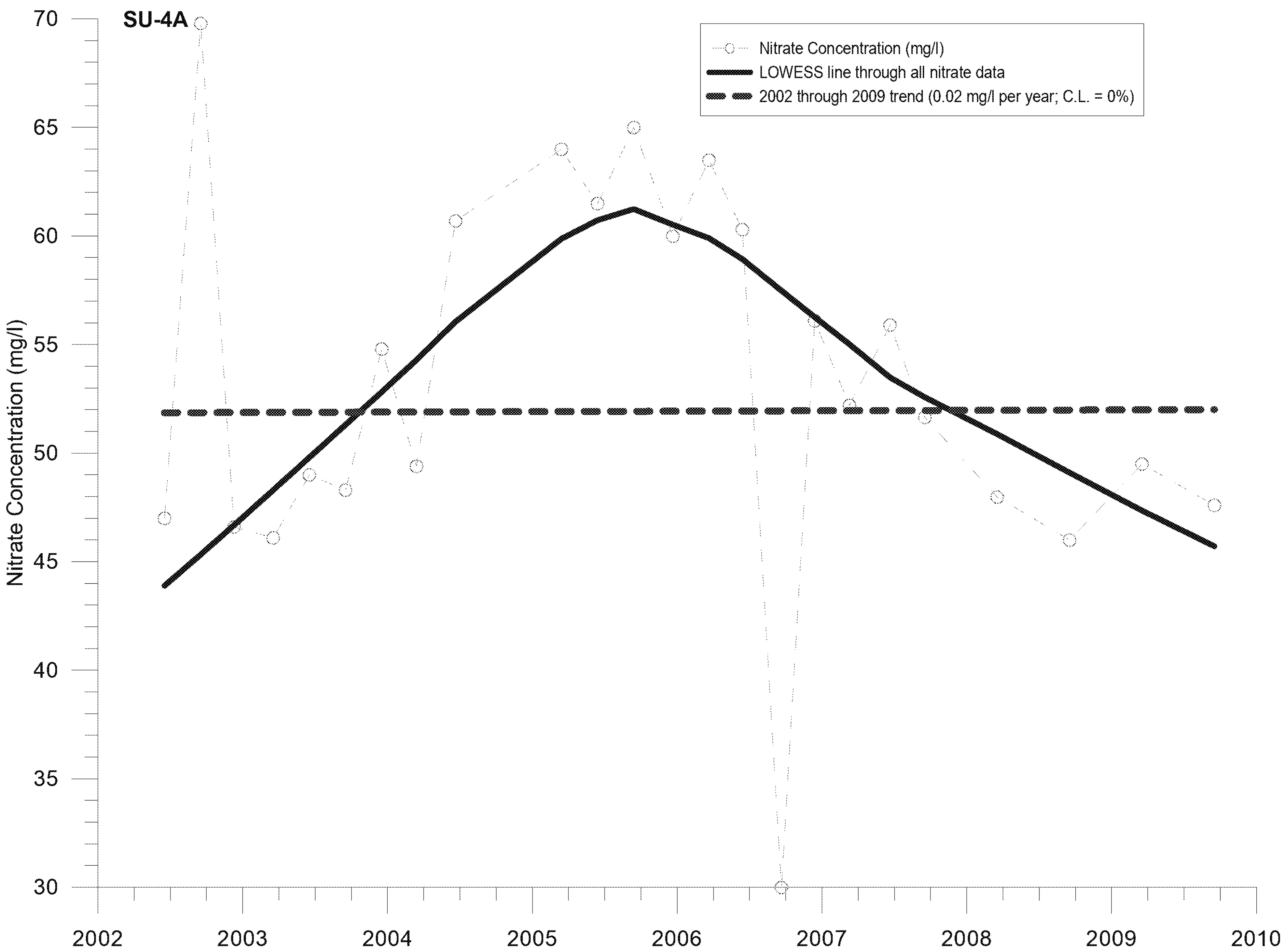


SU-1
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2000 through 2009 trend (-0.08 mg/l per year; C.L. = 90%)
note break in scale
Nitrate Concentration (mg/l)
35
30
15
10
5
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

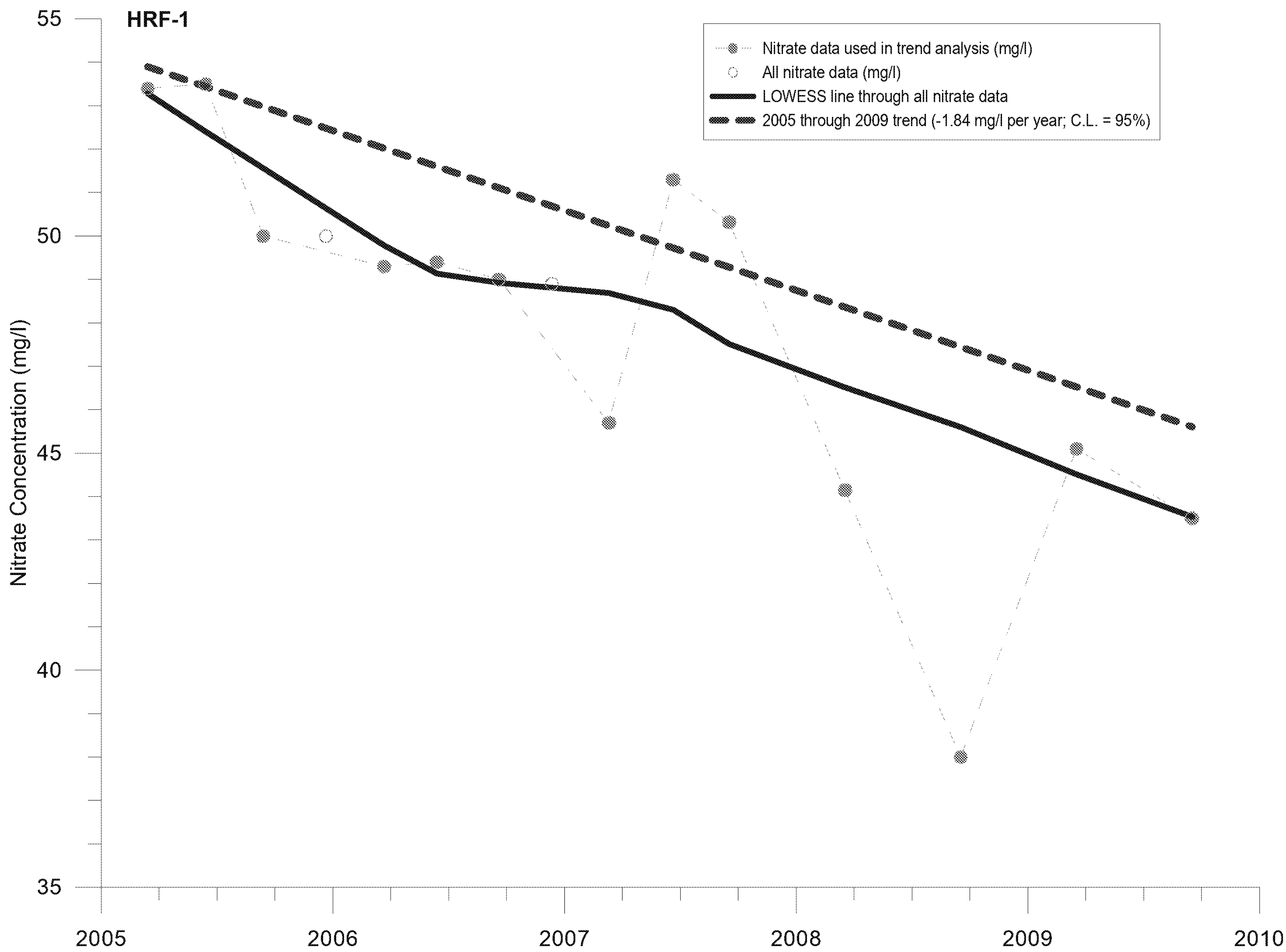

SU-2
Nitrate Concentration (mg/l)
LOWESS line through all nitrate data
2000 through 2009 trend (-0.11 mg/l per year; C.L. = 0%)
Nitrate Concentration (mg/l)
55
50
45
40
35
30
25
2000
2001
2002
2003
2004

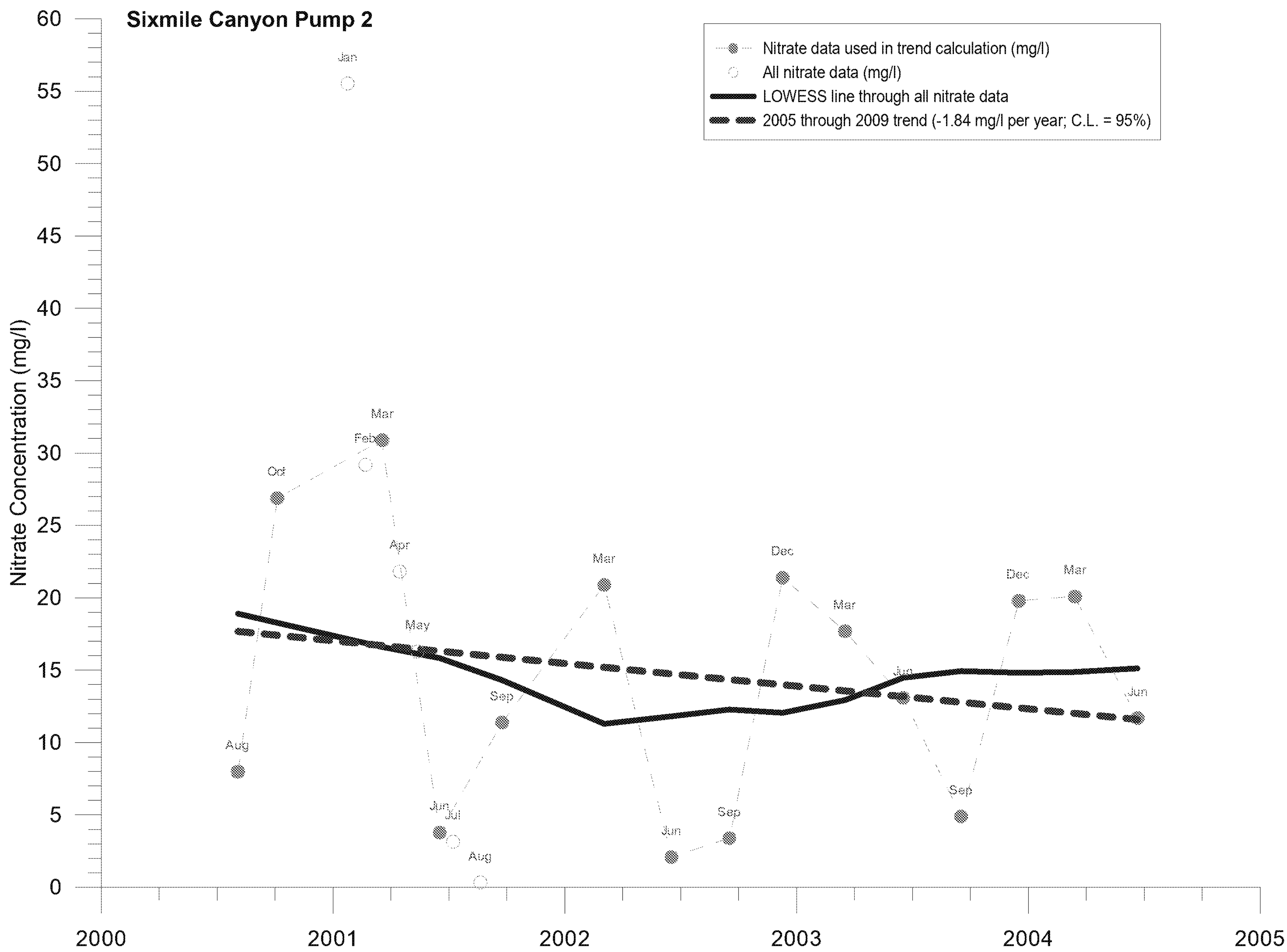


SU-3
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2000 through 2009 trend (-0.24 mg/l per year; C.L. = 78%)
Nitrate Concentration (mg/l)
45
40
35
30
25
20
15
10
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

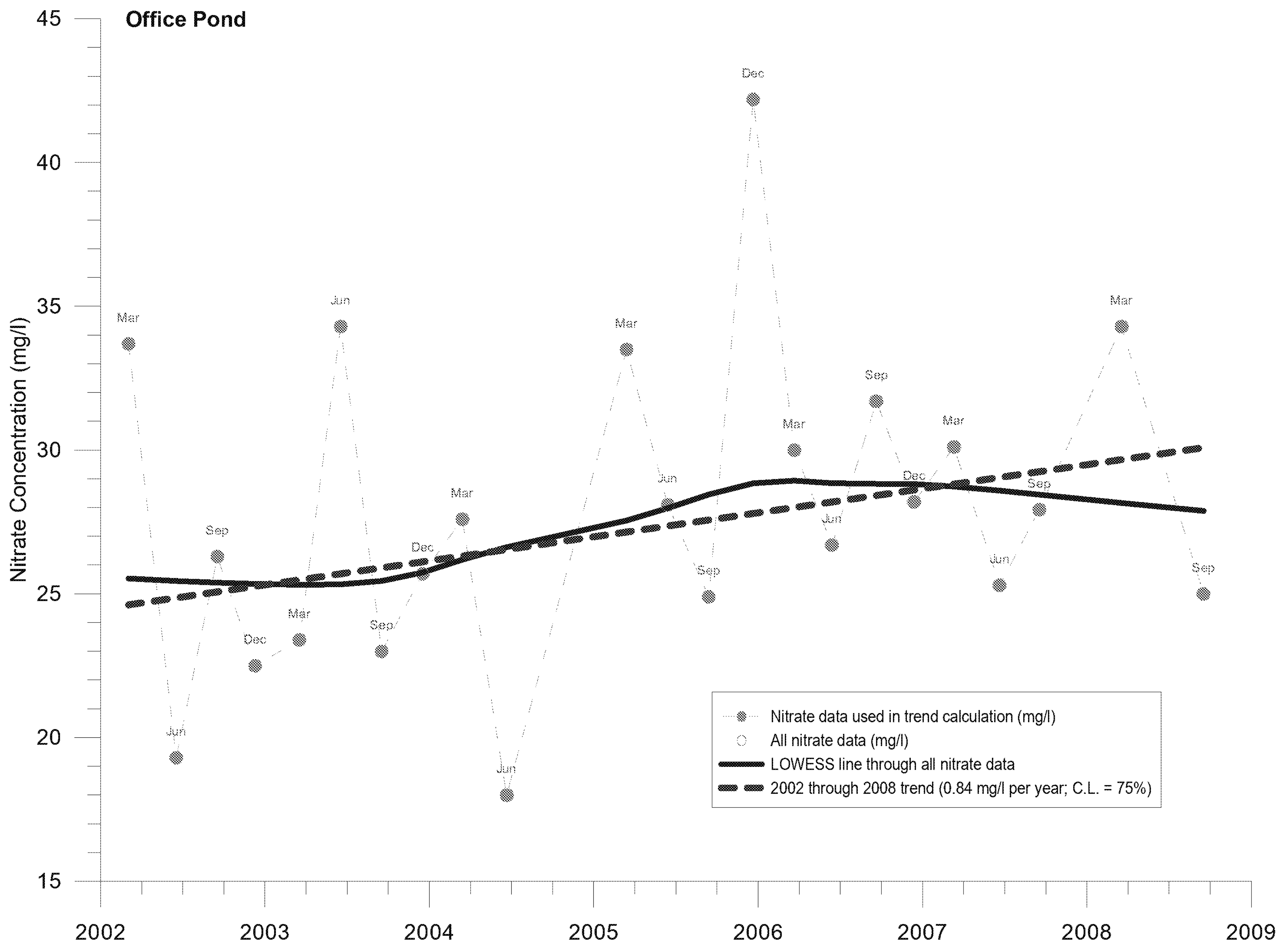


ED_005296_00001040-00126


HRF-1
Nitrate data used in trend analysis (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2005 through 2009 trend (-1.84 mg/l per year; C.L. = 95%)
Nitrate Concentration (mg/l)
55
50
45
40
35
2005
2006
2007
2008
2009
2010



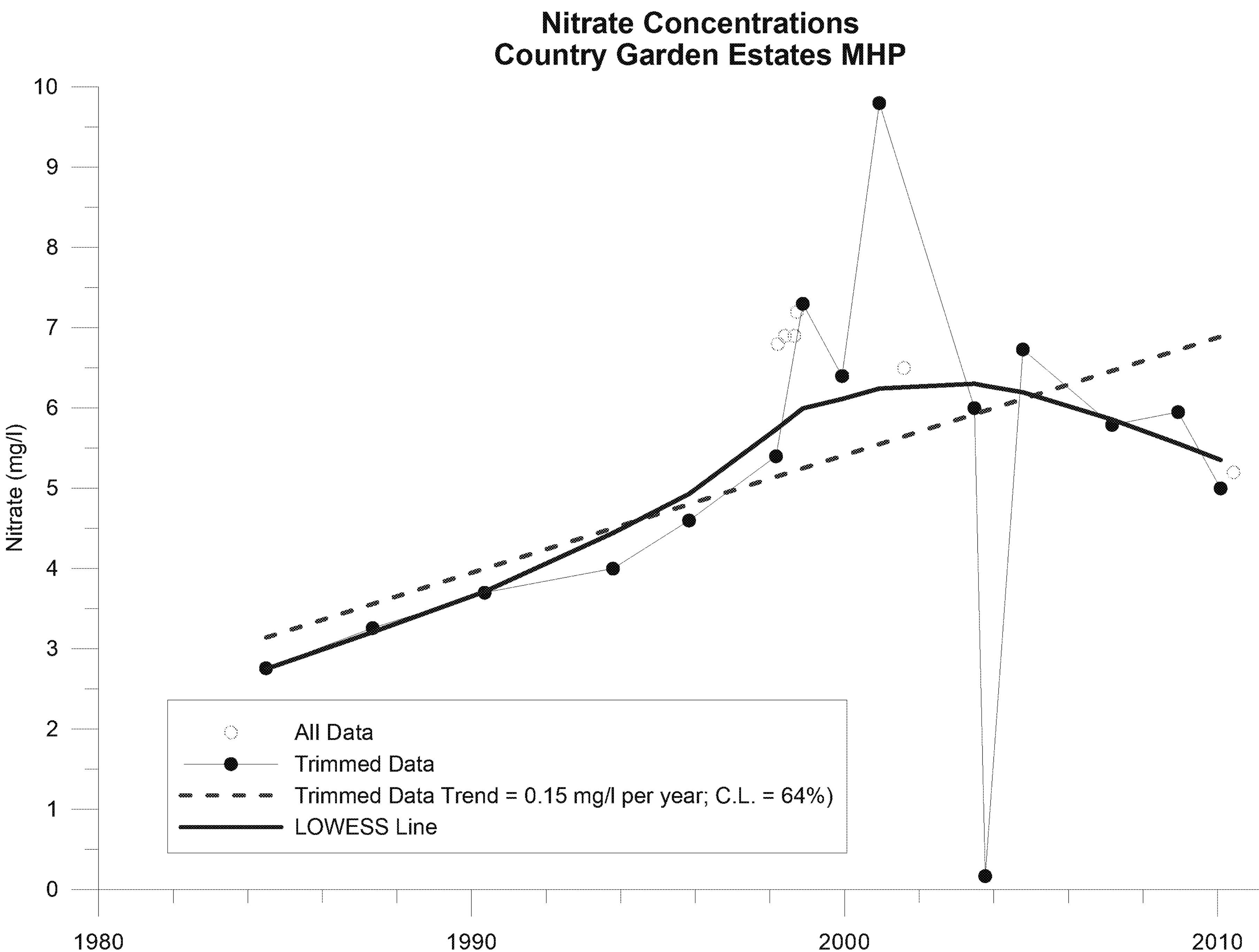
Sixmile Canyon Pump 2
Nitrate data used in trend calculation (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2005 through 2009 trend (-1.84 mg/l per year; C.L. = 95%)
Nitrate Concentration (mg/l)
60
55
50
45
40
35
30
25
20
15
10
5
0
2000
2001
2002
2003
2004
2005
Jan
Mar
Feb
Oct
Apr
May
Aug
Jun
Jul
Aug
Sep
Mar
Jun
Sep
Dec
Mar
Jul
Sep
Dec
Mar
Jun



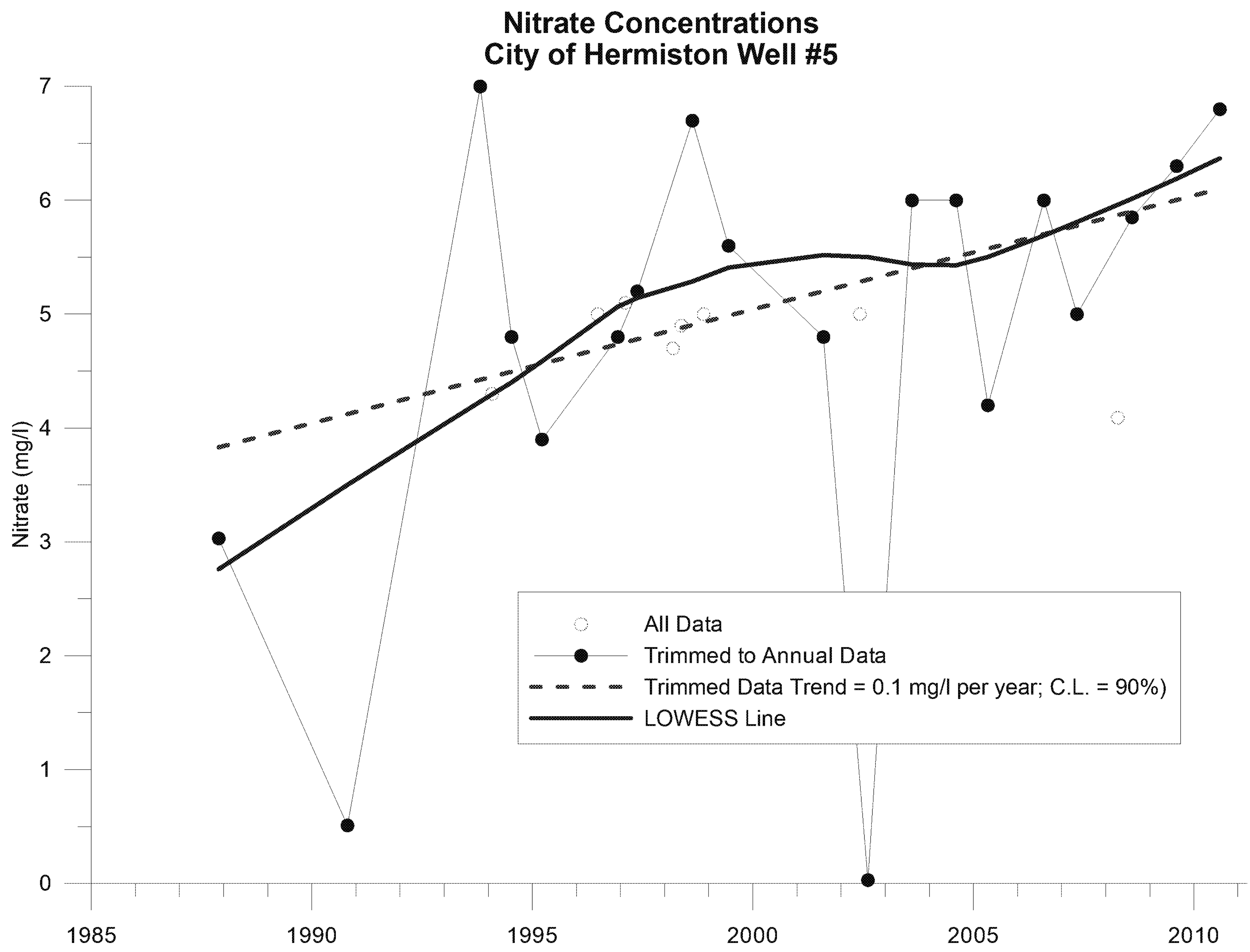
Office Pond
Nitrate Concentration (mg/l)
45
40
35
30
25
20
15
2002
2003
2004
2005
2006
2007
2008
2009
Mar
Jun
Sep
Dec
Nitrate data used in trend calculation (mg/l)
All nitrate data (mg/l)
LOWESS line through all nitrate data
2002 through 2008 trend (0.84 mg/l per year; C.L. = 75%)

Appendix C

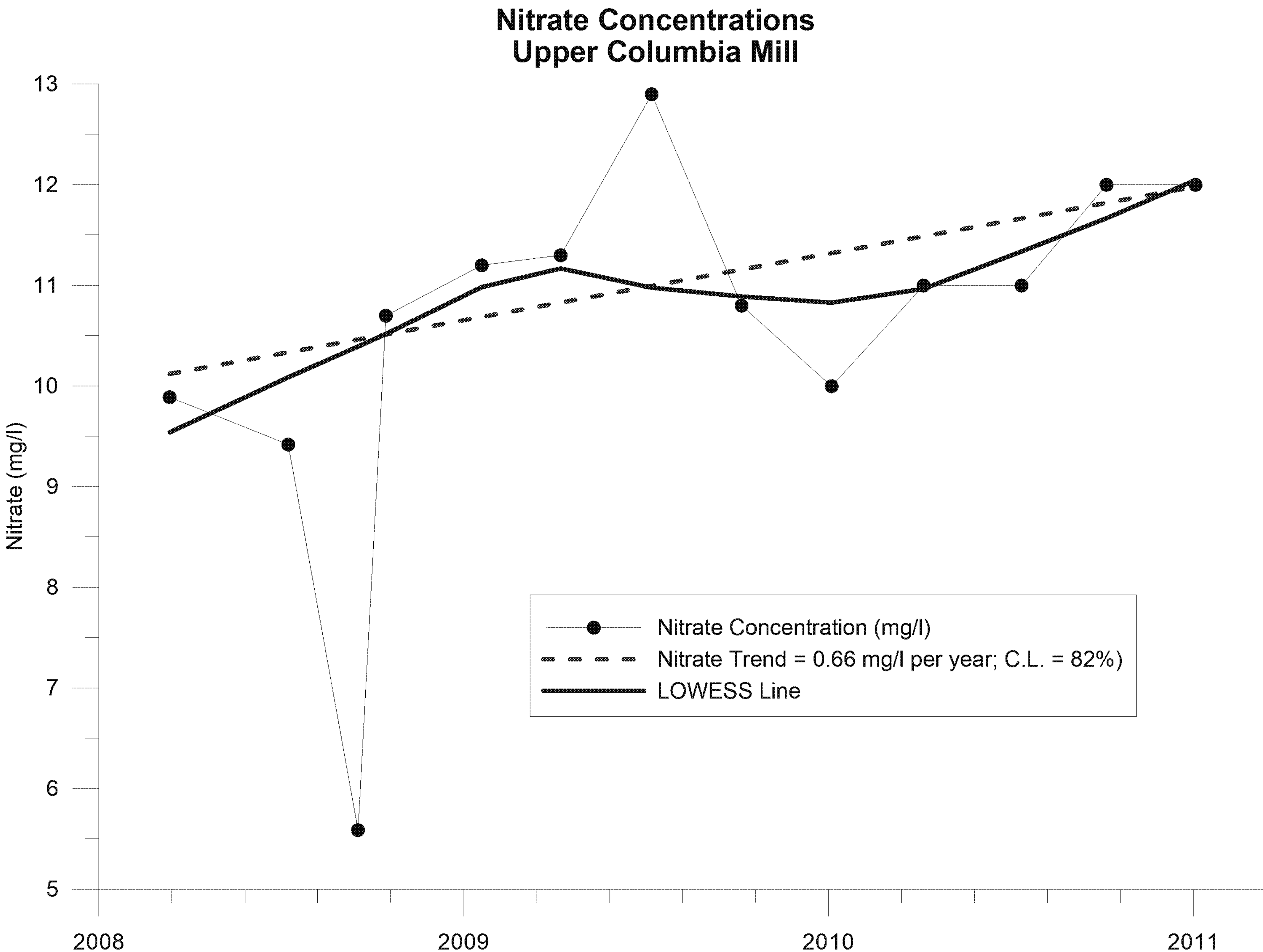
Time Series Plots for Public Water Supply Wells



Nitrate Concentrations
Country Garden Estates MHP
Nitrate (mg/l)
0
1
2
3
4
5
6
7
8
9
10
1980
1990
2000
2010
All Data
Trimmed Data
Trimmed Data Trend = 0.15 mg/l per year; C.L. = 64%)
LOWESS Line

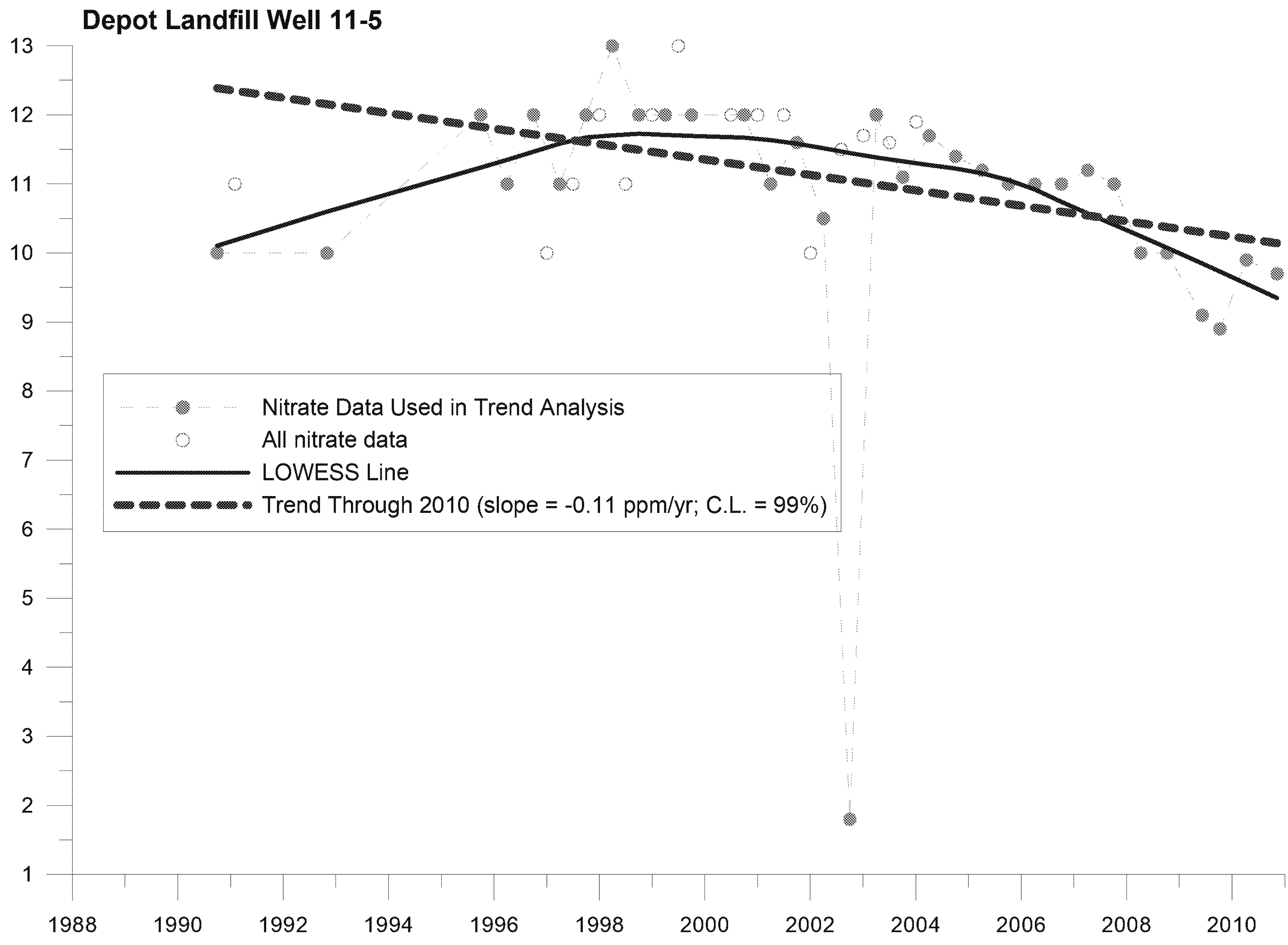


Nitrate Concentrations
City of Hermiston Well #5
Nitrate (mg/l)
7
6
5
4
3
2
1
0
1985
1990
1995
2000
2005
2010
All Data
Trimmed to Annual Data
Trimmed Data Trend = 0.1 mg/l per year; C.L. = 90%)
LOWESS Line

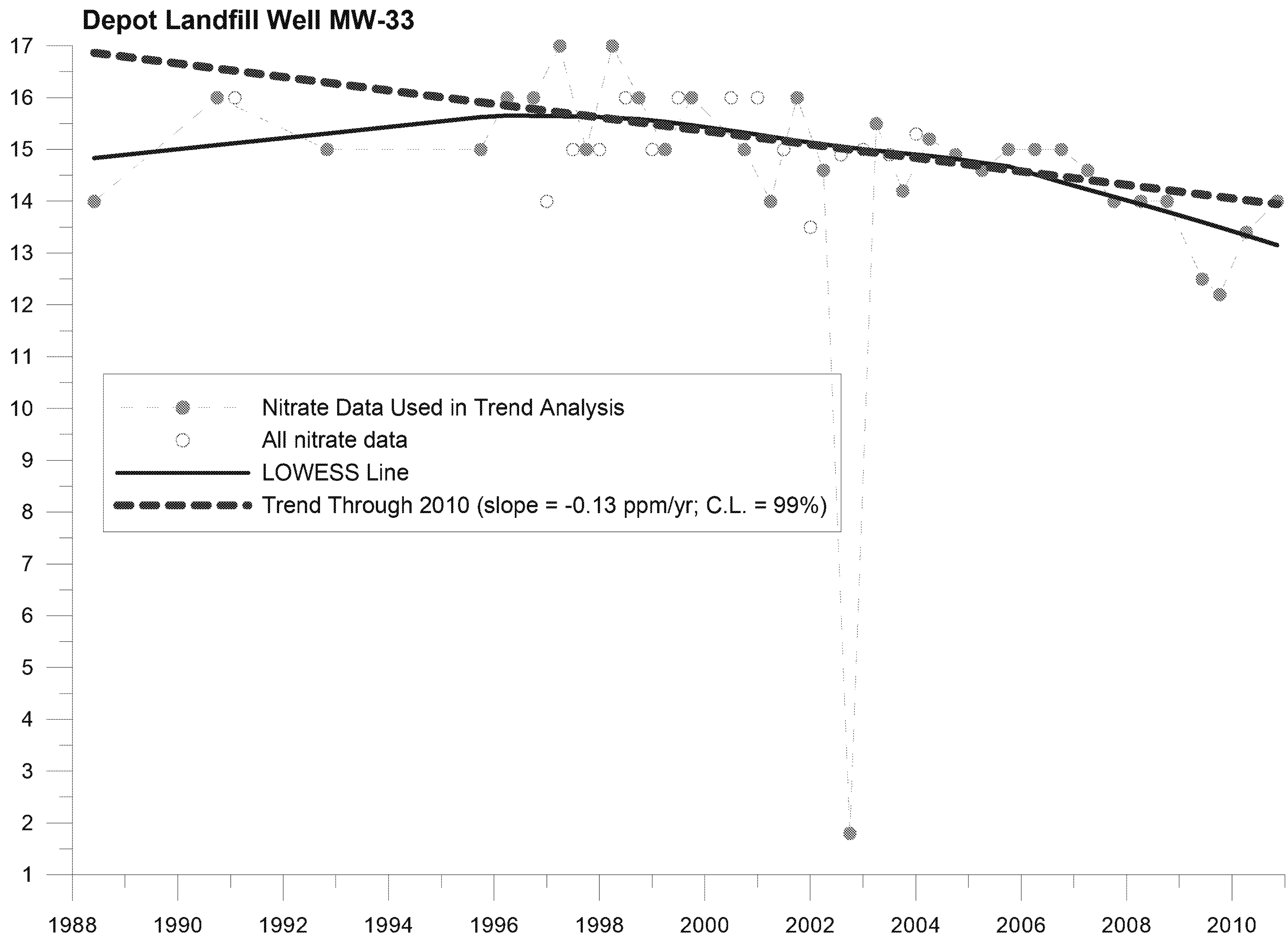

Nitrate Concentrations
Upper Columbia Mill
Nitrate (mg/l)
13
12
11
10
9
8
7
6
5
2008
2009
2010
2011
Nitrate Concentration (mg/l)
Nitrate Trend = 0.66 mg/l per year; C.L. = 82%)
LOWESS Line

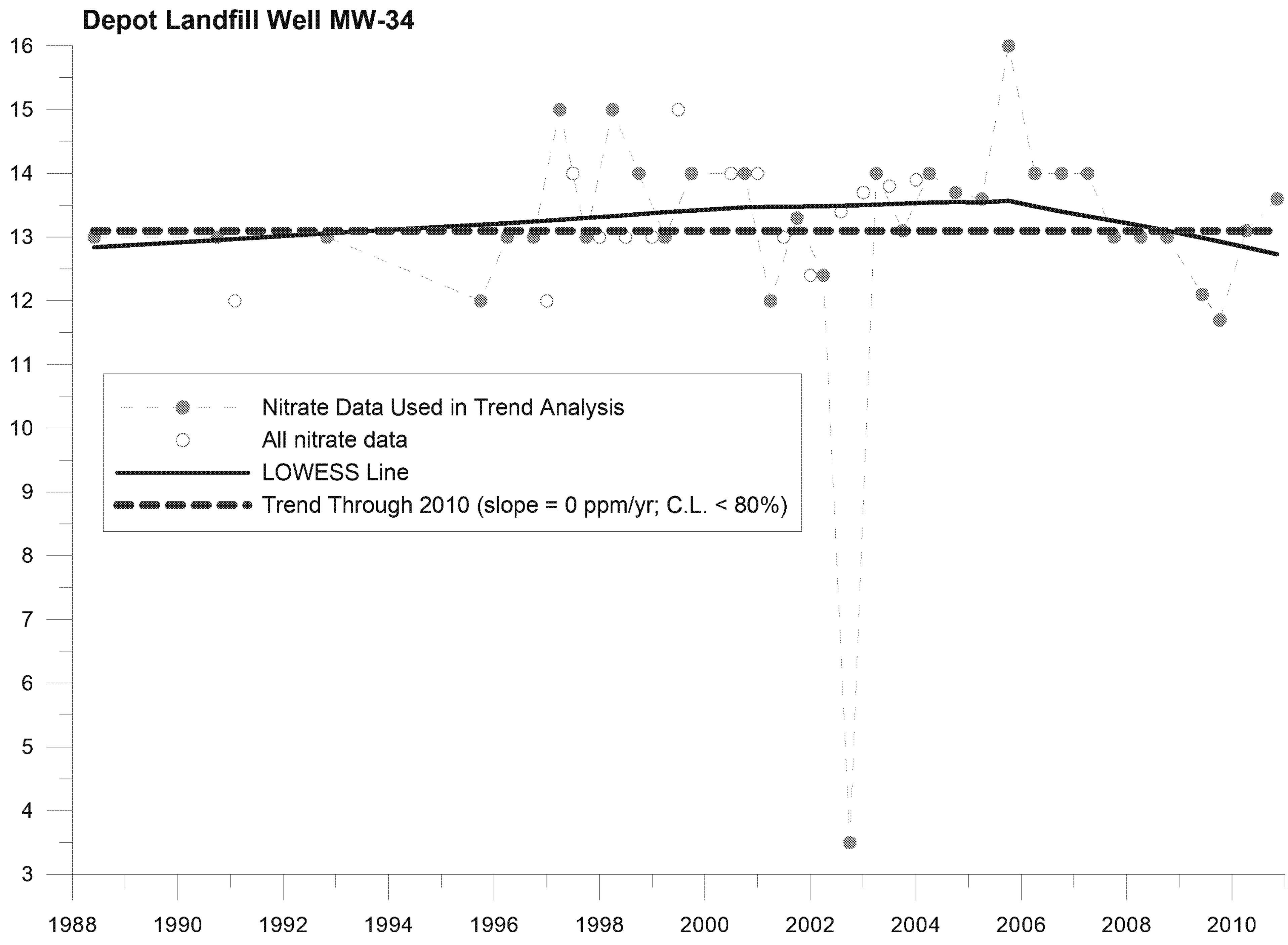
Appendix D

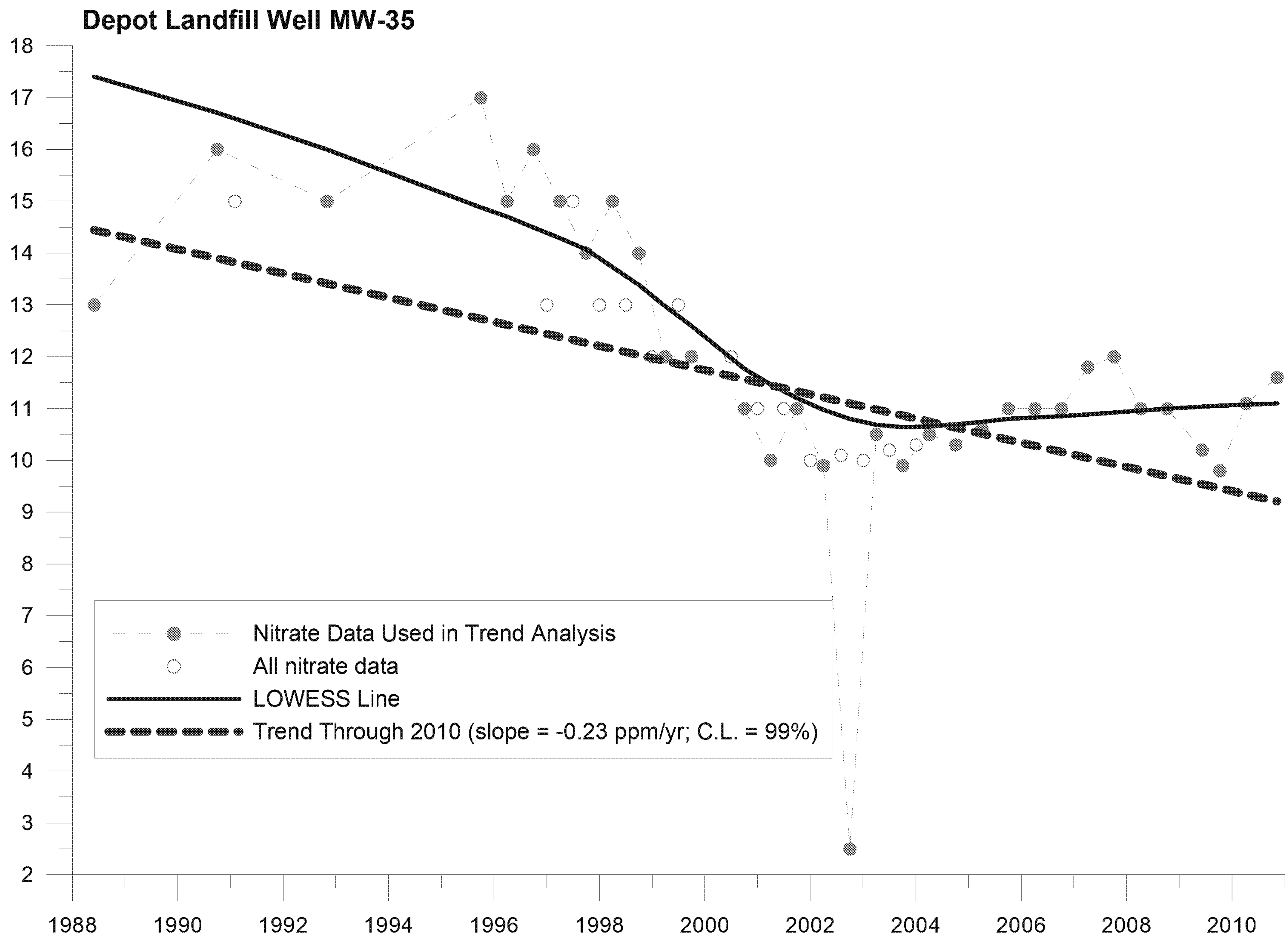
Time Series Plots for Depot Landfill Wells



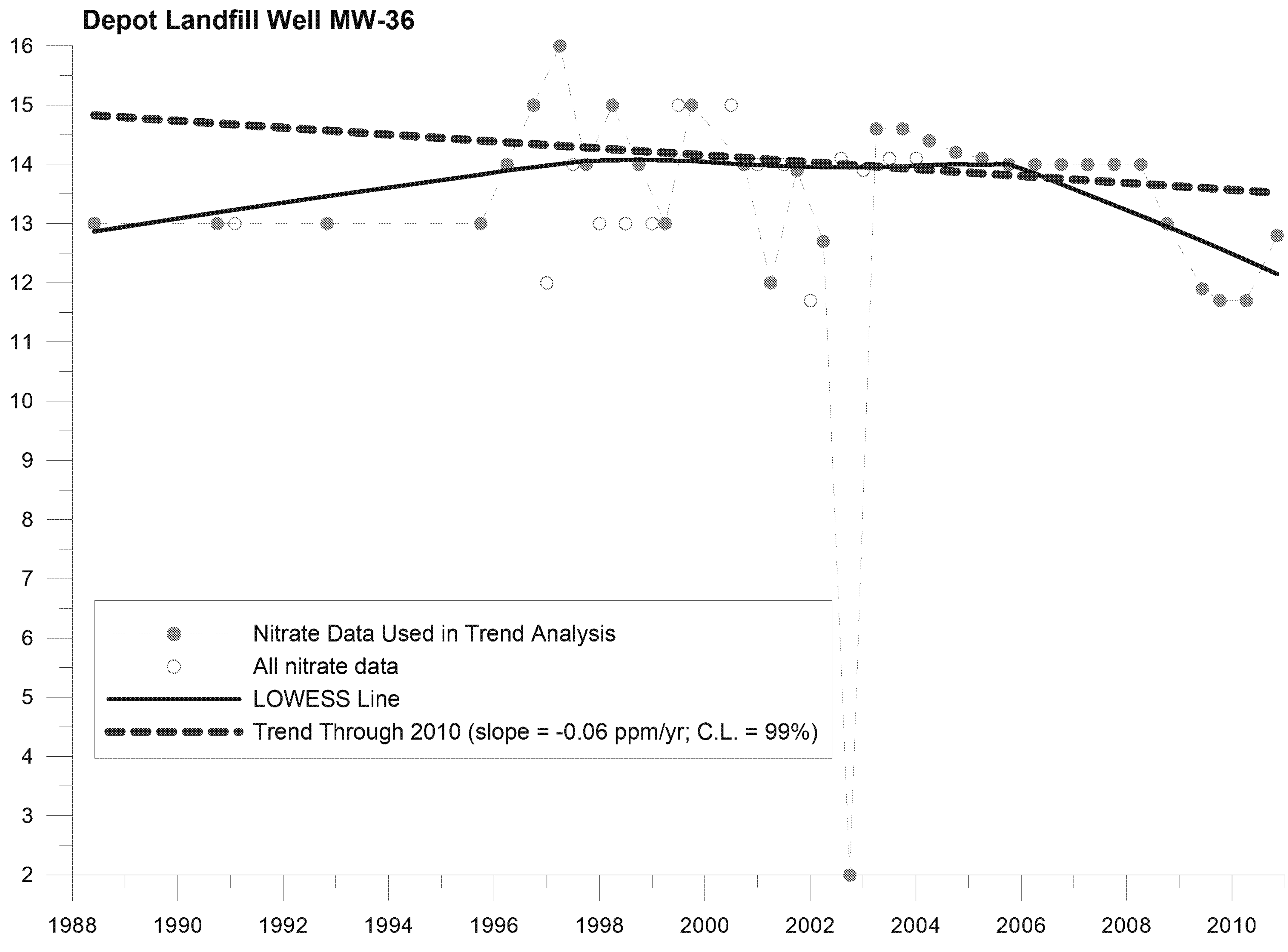
Depot Landfill Well 11-5
13
12
11
10
9
8
7
6
5
4
3
2
1
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Nitrate Data Used in Trend Analysis
All nitrate data
LOWESS Line
Trend Through 2010 (slope = -0.11 ppm/yr; C.L. = 99%)


Depot Landfill Well MW-33
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Nitrate Data Used in Trend Analysis
All nitrate data
LOWESS Line
Trend Through 2010 (slope = -0.13 ppm/yr; C.L. = 99%)


Depot Landfill Well MW-34
16
15
14
13
12
11
10
9
8
7
6
5
4
3
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Nitrate Data Used in Trend Analysis
All nitrate data
LOWESS Line
Trend Through 2010 (slope = 0 ppm/yr; C.L. < 80%)



Depot Landfill Well MW-35
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Nitrate Data Used in Trend Analysis
All nitrate data
LOWESS Line
Trend Through 2010 (slope = -0.23 ppm/yr; C.L. = 99%)



Depot Landfill Well MW-36
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Nitrate Data Used in Trend Analysis
All nitrate data
LOWESS Line
Trend Through 2010 (slope = -0.06 ppm/yr; C.L. = 99%)